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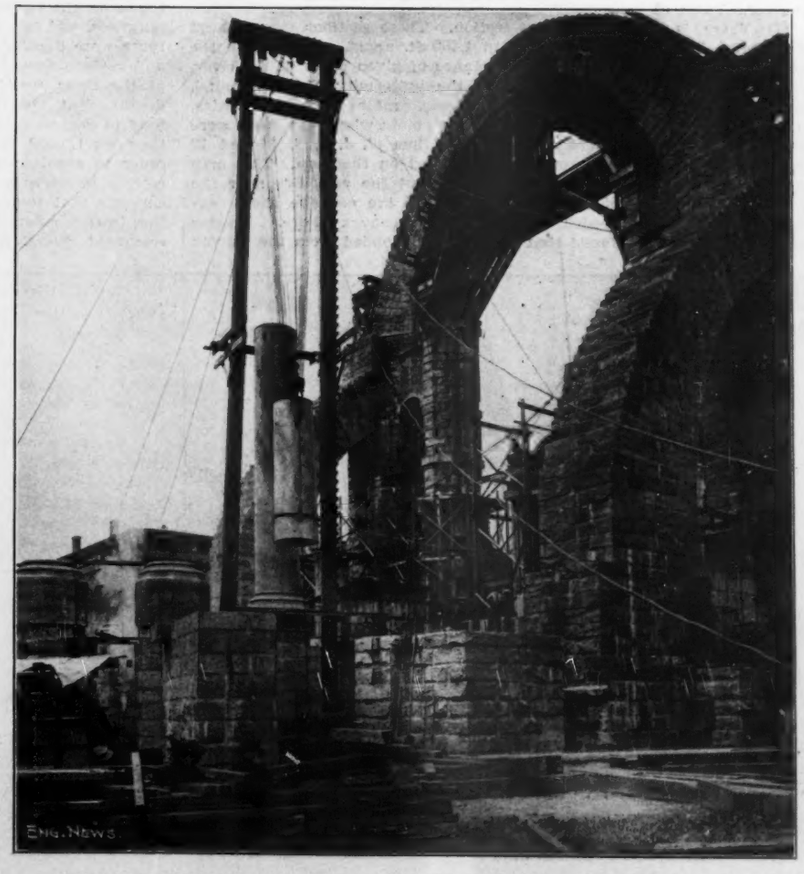
RAISING 90-TON COLUMNS AT THE CATHEDRAL OF ST. JOHN THE DIVINE, NEW YORK CITY.

The four photographs, reproduced herewith, require very little explanation to make clear the method used in raising the huge granite columns at the Cathedral of St. John the Divine. The gallows frame used in raising the columns consists simply of two legs or masts 96 ft. long, well guyed from the top, and tackle-blocks give 28 "parts" to the hoisting cable of ¾-in. wire rope. This cable is reeved through the blocks and its two free ends pass to the drums of two hoisting engines. By this arrangement, in case one engine is winding faster than the other, no unbalanced strain is put upon the cable or blocks.

Fig. 1 shows very clearly the method of securing the necessary hold upon the column. It will be seen that a 3-in. projecting ledge of rough granite has been left at the upper end of the column. A yoke, consisting of 14 × 14 in. timbers securely bolted together, is provided with two large U-bolts each of which secures a five-sheave block. In addition to these fastenings there is a lewis in the center of the end of the column to which a single block is attached. Three more single blocks are fastened by short loops of wire cable to the yoke.

Fig. 2 shows a runway of heavy timbers upon which the column rests before the lifting begins. The lower end of the column is provided with two large iron dowel pins which rest upon a rough carriage that travels along the runway on rollers as the upper end of the column is raised. To prevent "moving by jerks," a rope, shown in Fig. 2, is wrapped around the lower end of the column and its free end carried back to a hand winch by which the movement of the lower end of the column can be controlled.

Fig. 3 shows the column in position ready to be lowered upon the base prepared to receive it. After the column has been set, the yokes, etc., are removed, and the rough top of the column is taken off by plug and feathering, and is dressed to receive the upper section of the column which is raised as shown by our first-page picture. In our issue of Dec., 1903, the moving of these columns from the boat to the cathedral site was described, and the cutting of the columns in a lathe at the quarry was illustrated. As stated in that article, an attempt was made to cut a column 54 ft. long, but it broke of its own weight in the lathe. Each column was, therefore, made in two sections, one 36 ft. long and one 18 ft. long. The longer section weighs 90 tons, so that each leg of the gallows frame has to support a weight of 90,000 lbs., not including the weight of the guy lines, etc. The timber of these legs is Washington fir, brought overland from Seattle. The lower half of each leg is hewed so that the diameter is 24 ins. from the middle to the butt of the stick.



RAISING THE UPPER SECTION OF A GRANITE COLUMN FOR THE CATHEDRAL OF ST. JOHN THE DIVINE, AT NEW YORK CITY.

Johnson's formula for the breaking load on a column of Southern yellow pine is:

$$p = 4{,}000 - 0.8\left(\frac{l}{d}\right)^2.$$

Washington fir is probably fully 20% stronger than yellow pine, and free of knots, hence one is on the safe side in applying the above formula to these 96-ft. columns.

$$p = 4{,}000 - 0.8\left(\frac{96}{2}\right)^2 = 2{,}157 \text{ lbs. per sq. in.}$$

Since the cross-section area of each column is about 450 sq. ins., its breaking strength is not less than 450 × 2,157 = 970,650 lbs., which gives a factor of safety of fully 10.

Jones Bros., of Boston, Mass., have the sub-contract for erecting the granite columns, and their superintendent directly in charge of the work is Mr. Willis F. Howland.

RECENT RUSSIAN STUDIES OF FLOW IN RIVERS.

In our Engineering Literature Supplement for June 16, 1904, there appeared a brief review of Professor Tiapkin's Hydraulic Experiments. The original work is in Russian; and as it gives us the results of some very recent experiments, not yet known in the United States, a translation of some of the more interesting parts has been made for us by Miss Olga Simin, through the courtesy and with the co-operation of Mr. John C. Trautwine, Jr.

The work itself relates to the measurement of flow in channels, and presents a general outline of the present practice and results. The German and French data used are in general well known to American engineers; but Professor Tiapkin also described some important investigations hardly known at all in the United States, and some account of these may be of interest.

Chief among these experiments are those of Engineer Leliavsky, whose paper on the subject was discussed at the International Congress on River Navigation, held at the Hague in 1894.

Engineer Girardon, who has been working on the Rhone in the same lines, fully agrees with the views of Leliavsky, and regards them as "especially convincing"; and he refers to the works of Leliavsky as "a noteworthy event in hydraulics —a revolution."

The chief principle for which Leliavsky contends is that water does not move in parallel lines, as is so often assumed, but in currents, forming various angles with the vertical and horizontal. He has worked on the rivers Dnieper and Desna, using various instruments, some of which were designed by him. Leliavsky's apparatus consists of two parts: a subaqueous direction-indicator, and the current-meter proper. The vane indicates the direction of the current; and the current-meter gives the velocity. The combination of the two renders it possible to determine more accurately than with the Amsler meter the quantity of water passing through a given section. The vane is constructed on one of two types: (1) The more simple type, which must be taken out of the water for each observation. (2) A more complicated type, which gives the reading while in water. In each type the vane revolves on two axes, a vertical and a horizontal axis, thereby giving the readings of the direction as referred to both axes. With the second type the fluctuations of the current may also be observed. The current meter may be used with either type of vane, and its readings may be taken without removing the instrument from the water, the transmission being effected mechanically. Professor Tiapkin thinks, however, that the use of an electric transmission in the meter would be an improvement.

Professor Leliavsky made a series of observations on the Dnieper, near Kieff, by the use of floats, which enabled him to determine the directions of currents near the surface of the river. These observations have shown that: (1) There is no point in the river where all the currents are parallel. (2) There are, on the water surface, points toward which floating bodies tend from all sides. (3) On the other hand, there are on the surface points where, if two floats be placed near one another, they will invariably separate from each other within a certain distance.

The observations were made in still weather, and by means of a plane-table. The paths of the floats were marked on a map, by recording their position at the moment of their passage over a given cross-section. These sections were spaced from 140 ft. to 1,400 ft. apart, according to the degree of importance of given parts of the river, or according to the uniformity of its channel. The paths of the floats, profiles of their velocities, and lines uniting the points where the floats were found after a given time (2, 4, 6, 8, 10 and 12 minutes) were all noted on the map. This map then plainly showed that the velocities near the channel and those near the concave shore exceeded those near the convex shore. It was found that all the floats tended from the convex shore toward the concave shore and toward the channel. Hence, the most rapid surface currents were not parallel to the shores. The tendency of the water toward the channel causes considerable discrepancies between the actual flow and that determined by the usual methods; and these discrepancies are often much greater than are allowed for in the measuring devices.

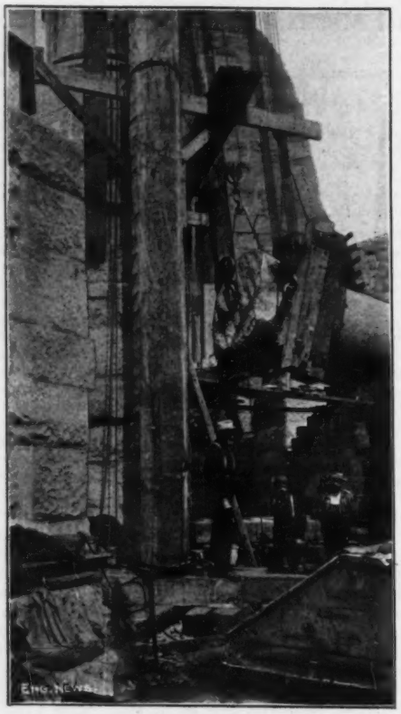


Fig. 1. View Showing Upper End of Granite Column at Beginning of Raising.

In gaging the flow of streams, it is usual to take plane cross-sections normal to the trend of the shores, it being assumed that the currents are parallel to one another and to the shores. But Leliavsky's observations show that the principal currents form more or less acute angles with the shores. The tendency of the currents toward the channel and toward the concave shore (or, in general, from the shallower to deeper places) causes boats and rafts to drift toward deep water, and is thus an advantage in their navigation. It is especially noticeable in the course of winding streams in mountainous regions.

The high velocities sometimes found near the convex shore are explained by the fact that the water flowing toward the channel and toward the concave shore, and having no other outlet, rises upon itself, forming a transverse slope from the channel and concave shore down to the convex shore, and thus generating bottom-currents flowing in the reverse direction, or from the channel to the convex shore. This phenomenon, long known, could be only experimentally studied with the aid of the subaqueous vane. These bottom return currents are the cause of the triangular cross-sections of rivers. If it were not for them, the cross-sections would be more nearly trapezoidal.

The laws governing the flow of rivers, as ascertained by Leliavsky, have an important bearing upon the regulation of rivers for navigation purposes. If, as is usually assumed, the currents were parallel, then, with a given discharge and surface elevation, a reduction of the breadth of the river would result in an increase in its depth. But now it appears that the currents tend to deepen only that part of the river where they meet, and tend downward. Therefore, in order to regulate a channel, it is necessary not merely to narrow it, but also to so direct the currents that some of them shall always meet at the desired point in the channel. Thus, in unregulated rivers, it may easily happen, even in

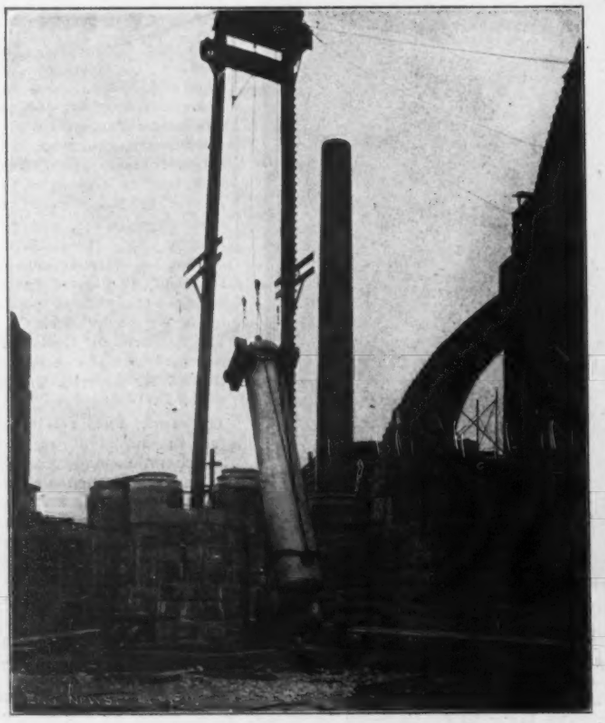


FIG. 2. VIEW SHOWING BASE OF GRANITE COLUMN SUPPORTED BY ROLLERS.

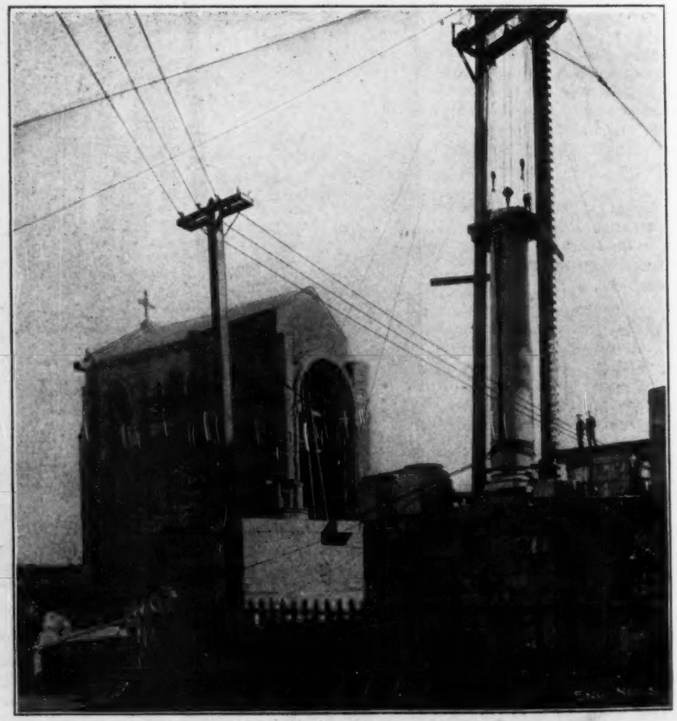


FIG. 3. LOWER SECTION OF GRANITE COLUMN ALMOST IN PLACE.

TABLE A.—Maximum Horizontal Deflections of Currents.

Number of cross-section.	Number of points in the cross-section.	Maximum angle of horizontal deflection, in degrees.	Angle of corresponding vertical deflection of the same currents in degrees.
1	16	59	?
2	23	72½	5 (down)
3	9	75	8 (down)
4	10	47	3 (down)
5	10	37½	?
6	7	22	4 (up)
7	19	78⅝	?
8	7	56	1° (up)
9	27	37	10 (down)
10	23	49	4 (down)
11	22	32½	?
12	6	37½	?
13	14	23½	2 (up)
14	24	40	19 (down)
15	11	28¾	?

Maximum Vertical Deflections of Currents.

Number of cross-section.	Number of points in the cross-section.	Maximum angle of vertical deflection, in degrees.	Angle of corresponding horizontal deflection of the same currents, in degrees.
1	1	6 (down)	6
2	24	19 (down)	23¼
3	8	24 (down)	14
4	21	15 (down)	17 3-5
5	1	8 (down)	4
6	6	15 (down)	15
7	1	13 (up)	½ to 2½
8	14	18 (up) and 11 (down)	26 3-5
9	9	10 (up)	25⅞ to 38 3-5
9	27	10 (down)	5
10	26	10 (up)	3½
11	9	10 (down)	3½ to 8
12	25	10 (up)	12½ to 16½
13	21	15 (down)	7⅞
14	2	5 (up)	3
14	13	26 (down)	19
15	21	15 (down)	20

wide reaches, that converging currents scour out a deep channel, and regulating works, although narrowing the channel, may defeat their own object by causing these hitherto converging currents to diverge. Professor Tiapkin considers it advisable to so locate regulating works that the concave shore shall always intercept the currents approaching it, and direct them against other approaching currents. He regards this, however, as a problem requiring further study.

After concluding his observations on the Dnieper, near Kieff, by means of floats, Mr. Leliavsky, in 1893, began a series of observations on the same river, near the city of Ekaterinoslav, using his vane. These observations led to conclusions, the most important of which are as follows: (1) Currents were found to diverge both in horizontal and in vertical planes; or

	Horizontal.	Vertical.
The maximum converging angle.....	89°	29°
The maximum diverging angle.....	108⅓°	17°

All the cross-sections were in these cases taken in directions approximately normal to the shores, and the deflection of currents from the normal reached as great an angle as 78 1-3°.

(2) The directions of currents located one over the other, measured in the horizontal plane, are in the majority of cases divergent; and sometimes the angle is quite noticeable, reaching 76°.

(3) The distribution of currents in the vertical plane was found to be analagous to the movements of atmospheric air; or, the direction of the lower currents was found to be mostly downward. This is caused by the resistance of the bottom of the river and by the friction between it and the water, and occurs only in the lower third of the depth. It is probably in this part of the river section that the transportation of alluvium occurs. In many places the upper currents were found to have a slight upward direction. This was evidently caused by the friction against the air. In the middle of the channel the currents are in general perfectly horizontal, or tend slightly upward when approaching shallow places in the river, where the currents diverge horizontally. Converging currents, and sometimes those deflected from the shores, flow downward. When a considerable horizontal divergence of currents was found, there was also apparent a noticeable downward flow, forming as great an angle as 24° with the horizontal. The greatest angle of deflection of currents from the horizontal was 18° upward, and 26° downward.

(4) In the majority of cases bottom-currents tend toward the shores and toward shallow places, but these deflections are not very noticeable.

TABLE B.—Maximum Horizontal Deflections of Currents.

Number of profile.	Number of points in the profile.	Maximum angle of horizontal deflection, in degrees.	Angle of corresponding vertical deflection of the same currents, in degrees.
1	2	15⅜	7 (up)
2	8	8 3-6	0
3	1	28½	3 (up)
4	11	42½	0
5	9	34	2 (down)
6	13	45½	5 (down)
7	11	53 4-7	2 (down)
8	13	46½	0
9	11	19 3-7	4 (up)
10	10	30	0
11	7	32	0
12	7	25	2 (down)
13	7	14 4-5	0
14	8	46⅜	4 (down)
15	8	54 2-5	3½ (down)
16	9	50	1½ (down)
17	8	59	8 (down)
18	1	42⅔	5 (up)
19	2	23½	3 (up)
20	4	18 3-5	4 (up)
21	5	15½	3 (up)
22	1	29 1-6	3½ (down)
23	6	16½	3 (up)
24	6	7½	4 (up)
25	2	12 1-5	1 (up)
26	9	14	0
27	9	8	4 (up)
28	9	35¾	3 (down)
29	5	15¾	2 (down)
30	11	32	0
31	9	15	2 (up)
32	6	17½	6½ (up)
33	8	20	5 (up)
34	8	24	6 (up)
35	2	26 1-7	5 (up)
36	1	22¼	3 (up)
37	1	23	3 (down)
38	4	20 1-3	13 (down)
38	5	23½	6 (up)
39	3	22¼	5 (up)
40	4	19⅔	5 (up)
41	4	20½	5 (down)
42	6	27 1-10	4 (up)
43	4	14½	5 (up)
44	3	28½	5 (up)
45	5	33 1-10	8 (up)
46	4	19 5-6	6 (up)
47	1	11 4-5	1 (up)
48	2	17 1-9	4 (up)
49	5	23½	8 (up)
50	2	19⅞	10 (up)
51	1	22	5 (down)
52	1	37	2½ (up)
53	1	28¼	6 (up)
54	2	14 1-9	3 (up)
55	1	22 1-7	5 (down)
56	6	14	9 (up)
57	2	13½	6 (up)
58	6	16⅞	3 (up)
59	6	17¼	4 (up)
60	5	18¾	7 (up)
61	4	10⅞	5 (up)
62	7	25½	10 (up)
62	7	24	6 (down)
63	7	25	8 (up)
64	2	30¾	3 (up)
65	1	27⅜	5 (up)
66	2	29½	4 (up)
67	1	15½	5 (up)
68	2	26	6 (up)
69	3	17¾	7 (up)
70	4	1 1-9	10 (up)
71	6	14½	2 (down)
72	7	23	8 (up)
73	1	16½	5 (up)
74	7	19⅔	4 (up)
75	1	17	9 (up)
76	1	17	5 (up)
77	1	12½	6 (up)

Maximum Vertical Deflections of Currents.

Number of profile.	Number of points in the profile.	Maximum angle of vertical deflection in degrees.	Angle of corresponding horizontal deflection in degrees.
1	2	7 (up)	15⅜
2	3	8 (up)	7½
2	5	6 (down)	1 2-7
3	3	6 (up)	13 3-7
3	2	5 (down)	12
4	3	9 (up)	7
4	6	9 (down)	4¼
5	1	10 (down)	½
5	4	4 (up)	8 7-9
6	13	5 (down)	45½
6	7	5 (up)	18½
7	11	2 (down)	53 4-7
7	4	4 (up)	2¾
8	2	8½ (down)	2 6-7
8	14	6 (up)	2⅝
9	6	10 (down)	10
9	11	6 (up)	53½
10	1	4 (down)	¾
10	3	5 (up)	2
11	1	5 (down)	3 4-5
11	3	5 (up)	3-7
12	3	5 (up)	1½
12	10	12 (down)	12
13	4	6 (down)	3 7-9
13	5	5 (up)	7⅞
14	2	5 (up)	14⅝
14	8	5½ (down)	40 3-5
15	3	5 (up)	17½
15	9	8 (down)	37½
16	2	5 (up)	19 1-6
16	3	13 (down)	10½
17	4	3 (up)	23
17	8	8 (down)	50
18	7	18 (down)	1½
18	3	4 (up)	10
19	2	5 (up)	24½
19	6	4 (down)	½
20	2	5 (up)	5 3-5
20	5	8 (down)	10½
21	5	6½ (up)	12
21	4	15 (down)	3
22	6	5 (up)	15½
22	1	3½ (down)	29 1-6
23	7	4 (up)	3½
23	4	5 (down)	8 7-10
24	3	5 (up)	8
24	2	10 (down)	2 1-10
25	5	5½ (up)	4
25	7	4 (down)	4½
26	7	7 (up)	4⅔
26	2	5½ (down)	3⅞
27	9	4 (up)	8
27	6	11 (down)	6 1-6
28	4	5 (up)	5 1-10
28	9	3 (down)	35¾
29	4	6½	1-6
29	3	10 (down)	3
30	3	7 (up)	7
31	4	7 (up)	2 4-7
31	3	2 (down)	3 2-5
32	5	7 (up)	10
33	4	7 (up)	13 1-9
33	12	1 (down)	½
34	1	6½ (up)	10½
34	6	5 (down)	13 9-10
35	7	6 (up)	9¾
35	6	7 (down)	1⅜
36	8	6 (up)	4 9-10
36	4	5 (down)	5½
37	1	6 (down)	18 3-10
37	5	7 (up)	2¾
38	7	8 (up)	5⅝
38	4	13 (down)	20⅞
39	5	7½ (up)	19½
39	7	10 (down)	19¾
40	1	5 (down)	8⅝
40	6	8 (up)	8¼
41	4	5 (down)	20½
41	1	9 (up)	5½
42	3	7 (up)	4
42	4	5 (down)	4
43	4	8 (up)	9
43	5	1½ (down)	10½
44	3	5 (up)	28½
44	2	15 (down)	3¼
45	5	10 (up)	23 1-5
46	4	10 (up)	18
47	1	7 (up)	10
48	2	10 (up)	6¼
49	5	9 (up)	19¾
49	3	9 (down)	12 1-6
50	1	16 (up)	10½
51	3	9 (up)	9
51	1	5 (down)	22
52	1	10 (up)	28 1-6
52	1	4 (down)	28¼
53	1	10 (up)	28 1-9
54	2	11 (up)	8⅛
54	4	4 (down)	11
55	1	6 (down)	15⅝
55	5	11 (up)	3⅛
56	5	11 (up)	2
56	1	3 (down)	10
57	4	12 (up)	7-10
57	3	2 (down)	4 3-5
58	4	10 (up)	10 5-6
58	7	2 (down)	4
59	7	10 (up)	12 1-5
59	5	2 (down)	2⅜
60	4	13 (up)	12¾
61	2	8 (up)	2¼
61	7	8 (down)	7 7-10
62	7	10 (up)	23½
62	7	6 (down)	24
63	7	8 (up)	25
63	8	2 (down)	23 5-6
64	5	9 (up)	15
64	1	3 (down)	3
65	1	12 (up)	15 2-5
65	1	5 (down)	3
66	5	7 (up)	23 9-10
67	4	10 (up)	2¼
67	3	3 (down)	5 1-5
68	2	9 (up)	2¾
68	4	6 (down)	17
69	5	8 (up)	9 8-11
69	6	2 (down)	9 4-5
70	4	10 (up)	15 1-9
71	5	10 (up)	8 1-7
71	3	7 (down)	5-6
72	6	11 (up)	15½
73	4	10 (up)	2 2-5
74	4	10 (up)	3½
74	1	8 (down)	1
75	7	10 (up)	15
75	6	2 (down)	8¼
76	6	7 (up)	1
76	2	3½ (down)	8⅝
77	4	6 (up)	12½
77	3	1 (down)	6½

(5) Where currents meet, and for some distance down-stream, the channel is deepened; on the contrary, the channel shoals below the points where currents diverge. This result is independent of the width of the stream.

The maximum observed deflections of the currents, in the vertical and horizontal directions, are shown by Table A.

Mr. Leliavsky's final conclusions are as follows:

(a) The distribution of the currents in a river channel is not accidental. The vertical and the horizontal deflections are constant, so long as the surface and the river bottom remain constant.

(b) The subaqueous vane shows correctly the directions of the currents.

(c) The angle vibration of the end of the vane does not affect its readings.

Leliavsky's investigations on the Desna, in 1894, confirmed the results obtained on the Dnieper, in 1893. The maximum deflections of currents in 77 cross-sections are shown by Table B.

From these tables we see that in this case the maximum deflections were: In the horizontal plane, 59 5-7° (the simultaneous deflection in the

TABLE C.—Comparison of River Discharges by Ordinary and by Leliavsky's Method.

Number of profile.	Discharge in cubic sagens * Measured according to the ordinary method.	Actual discharge (Leliavsky's Method).	Excess in percentage of the actual discharge.
9	16.182	15.494	4 44
15	17.696	16.801	5.33
16	17.942	16.896	6.19
17	19.032	17.457	9.02
18	22 145	20.145	9.93
19	20.220	18.822	7.42
38	25.118	23.906	4.26
44	28.501	26.893	5.98
50	25.710	25.267	1.75
63	23.561	22.065	6.78
64	26.039	24.407	6.68
65	24,447	23.167	5.52
66	23.824	21.585	10.32
68	22.940	21.622	6.09
69	23.350	22.799	2 41
70	23.366	22.796	2 50
74	24 398	22.879	6.25
76	23.229	22.282	4.25

*1 cubic sagen = 49 cu. ft.

vertical plane being 4° upward); in the vertical plane, 16° upward (the simultaneous deflection in the horizontal plane being 10½°); or, 18° downward (the simultaneous deflection in the horizontal plane being 6½°). The observations thus show that the true cross-section of the river is really not a plane but a warped surface.

DISCHARGE OBSERVATIONS.—The foregoing observations are important, not only in connection with river regulation for navigation purposes, but also in connection with the determination of discharges. Manifestly notable mistakes are often made, when velocities—measured in cross-sections normal to the shores, are multiplied by corresponding parts of these cross-sections, which are supposed to be normal to the flow. We know now that in each cross-section the currents are inclined, forming some times quite acute angles. Hence, all the determinations of discharge, made in the usual way, give exaggerated results, and the degree of exaggeration is different in each case.

Table C gives a comparison of results obtained by Leliavsky on the River Desna.

It will be seen that the excess, by the usual method, here exceeds 10%, and this notwithstanding that the measurements were performed very accurately. Ordinarily the discrepancy would have been greater.

Another source of inaccuracy in current-meter measurements is the oscillation of the meter in the water. This is quite noticeable when the vane of the meter is short. The water shakes it

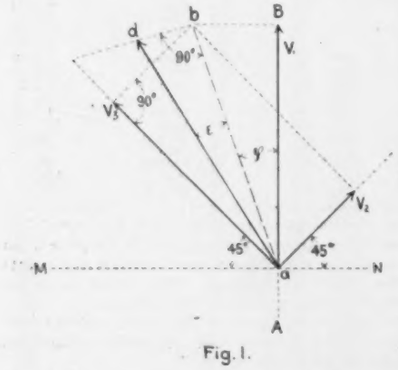


Fig. 1.

from side to side, affecting the revolution under the action of inclined currents. Hence it cannot show correctly the real velocities of the currents, but will always register less than the actual velocity. This is especially marked near the bottom of the stream, where, according to the observations, the vibrations of the instrument are greatest.

We should take, not the velocities themselves, but their projections normal to the cross-sections.

According to Professor Tiapkin this can be done with the aid of the following devices:

(1) The subaqueous vane of Leliavsky, combined with the current meter.

(2) The current meter of Harlacher, showing not the velocity, but its projection on a plane normal to the cross-section.

(3) If neither of these devices is available, fairly accurate results may be obtained by the use of a simple Woltmann current meter, three or five projections of the velocities being determined according to a special method, which Professor Tiapkin describes as follows:

On a horizontal plane (Fig. 1), passing through the point a, three velocity measurements are taken, as follows, by means of an ordinary current meter, so fastened to a vertical rod, at a, that its axis may be held at any desired position in the horizontal plane:

(1) Velocity V_1, perpendicular to the given cross-section M N of the river.

(2) Velocity V_2, 45° to the right of V_1.

(3) Velocity V_3, 45° to the left of V_1.

The number of revolutions of the current meters being in direct proportion to the cosine of the angle between the axis of the meter and the direction of the main current, the velocities V_1, V_2, V_3, may be regarded as projections of the horizontal component of the velocity V of the main current. Hence, perpendiculars, erected at the ends of the lines representing the velocities V_1, V_2, V_3, must intersect in some one point b. The line a b there expresses, by its length and direction, the horizontal component of the velocity V of the main current; φ is the angle formed by the direction of the horizontal component of the main current with the vertical plane A B, normal to the section M N.

The next operation (Fig. 2) is to measure two velocities, as below, in the vertical plane A B of Fig. 1, which, in Fig. 2, is the plane of the paper. For this purpose, the current meter must be so arranged that its axis can be held at any desired angle to the horizontal, in the vertical plane mentioned.

(4) Velocity V_4, 45° above the horizontal plane C D.

(5) Velocity V_5, 45° below the horizontal plane C D.

The velocities V_1, V_4, V_5 are projections of the vertical component of the velocity V of the main current; and, as in the preceding case, a line a c is obtained expressing, by its length and direction, the vertical component of the velocity V of the main current; E is the angle between the direction of the vertical component of the main current and the horizontal plane C D.

We now have in a b, Fig. 1, and a c, Fig. 2, the horizontal and the vertical projections of the velocity V, and from these it is easy to determine the actual velocity, V. Thus, in Fig. 1, at a, lay

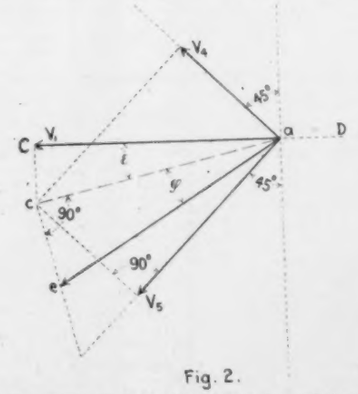


Fig. 2.

off the angle E from the line a b, and from the point b erect a line perpendicular to a b, and intersecting a d in d. Now, if the triangular plane a b d be revolved about a b, from the horizontal to a vertical position, the line a d will approximately represent the velocity V, in direction and in amount.

Similarly, in Fig. 2, at a lay off the angle φ from the line a c, and from C erect a line perpendicular to a c and intersecting a e in E. Now, if the triangular plane a c e be revolved about a c, from the vertical into the horizontal position, the line a e will (like a d in Fig. 1) approximately represent the main velocity V, both in direction and in amount.

SOME NOTES ON THE DESIGN AND BUILDING OF THE 21,000-TON STEAMSHIPS MINNESOTA AND DAKOTA.*

By Charles R. Hanscom,† M. Soc. N. A. & M. E.

Early in the spring of 1900, I received the contract to construct two large cargo steamers for Mr. J. J. Hill, President of the Great Northern Railway Co. I had previously looked for a suitable site along the Atlantic seaboard on which to establish a shipyard to build these large vessels. After a certain amount of deliberation, I decided to locate the yard at Groton, on the Thames River, opposite New London, Conn.

The arrangement of a shipbuilding plant in most instances depends on the nature and character of the ground. In shipbuilding generally, the plant is almost forgotten in the interest taken in the magnitude and cost of work being done; the value of the plants usually is small compared with the value of the output, except in a few notable instances in this country alone.

The suitable depth of water, natural solidity of the land, good railroad facilities, and splendid climatic conditions, made New London appear to be a very desirable place. I secured the strip of land formerly used by the New York, New Haven & Hartford R. R. Co. as terminus for their old line to Boston. The old round-house, built of brick, was left standing, and we used it for blacksmith shop and power house. An installation of four fire-tube boilers (furnishing steam at 125 lbs. pressure, and of 1,000 HP. capacity) was supplied. The coal is conveyed to these boilers by an overhead trolley from coal bin on coaling wharf. The plate and bar furnaces were built in close proximity to the main boilers, having flues leading to a common chimney. The plate furnace is 30 ft. long by 8 ft. wide, and the bar furnace is 73 ft. long. The furnaces are of the reverberatory type. The bending slabs, contiguous to the furnaces, cover an area of 4,000 sq. ft. An electric winch is fitted to facilitate the handling of the long and heavy frames. The frames in the midship part of the Minnesota and Dakota are 12-in. channel bars, weighing 36.8 lbs. per ft., much the largest and heaviest bars ever made in shipbuilding, the longest frame being 60 ft. and beam channel 73 ft. The lower ends of these frames were split for a distance of 8 ft., which made an extremely difficult frame to bend and handle. The angle-smith's shop is alongside the bending floor, and the general blacksmith shop is also under same roof.

The plate shop is a well ventilated building, and contains machinery for preparing the heavy shapes and plates. The heaviest plate on the ship is 1¼ ins. thick, and the heaviest shape was an I-section 80 lbs. per ft. This shop is fitted with punches, shears, planers, drills, mangle, rolls and flangers, scarfing machine, etc. The scarfing machine is the only one perhaps worthy of special notice, as it is somewhat different from the usual type, being a combined scarfer and planer; it is a milling machine, the heads being adjustable to width of plate, so as to scarf both landings simultaneously. A planing tool can plane the end of the plate while held in the same position. This machine we designed here to suit our widest plate. The usual crane for hoisting material is fitted over each machine, and a trolley conveys material from this shop to the erecting trolley. A rail track passes on the outside of building, and one runs through between punches. The material from the stock yard is brought in on trucks to the laying-out shed, which is situated at one end of plate shop. The machines in this shop are belt-driven by a steam engine, which develops 150 I. HP.

The pipe, plumbers', machine, joiner, and carpenter shops are all fitted with modern machinery, and belt-driven by a 230 HP. engine; this engine also runs the dynamo used for generating electric power for overhead trolley blowers, lighting, etc.

The overhead erecting trolley will be of interest, so I describe it somewhat in detail. This trolley, extending over the two adjoining shipbuilding berths, was designed to fulfill all the functions of an overhead traveling crane, at a much reduced cost, and to be more rapid in its working. Vertical, longitudinal, and transverse motion was secured by a transverse moving cable on which a carriage with hoisting gear moves longitudinally (see Figs. 1 and 2).

The entire structure was designed and built in the yard, and consists of three steel towers, each 120 ft. long, 42 ins. maximum diameter, 30 ins. diameter at base, and 24 ins. diameter at head. Each mast supports a steel cross-yard, rectangular in section, of lattice work construction, which is held in position by braces to head of mast, while center of yard is riveted to mast. Each yard is 174 ft. long and extends over two building slips, the masts being located between the vessels, one at stem and stern, and one half-way between. The masts are 300 ft. apart.

The yards are 4½ ft. deep by 5 to 6 ft. wide, in the center, reducing to 2½ to 3 ft. deep by about 3 ft. wide at ends. The end yards are well trussed by wire ropes passing round a horizontal strut 15 ft. long, projecting from the center of each end yard away from the hoisting field. The heel of each mast is a cast-iron ball, and

*Abstract of a paper read at the annual meeting of the Society of Naval Architects and Marine Engineers.

†President Eastern Shipbuilding Co., New London, Conn.

...ts in a cast-iron socket set on a wood crib over a natural granite rock foundation. The steel structure is held in position by wire guys, each yard being supported by steel guys from masthead, six being fitted on main yard and four on each end yard. From extreme end of each yard wire rope guys run to the ground and are securely fastened to granite anchorages. The yards are kept parallel to each other by means of wire guys from center of each and from ends of each, and are kept in rectangular position by diagonal guys from main mast to each extremity of end yards, and from end masts to extremity of middle yard. To prevent the whole from toppling in a fore-and-aft direction, wire stays are run from center and ends of end yards to ground anchorages. To assist these aft stays, a strong back, or strut, is fitted to after mast. This strut is built of steel and is rectangular in section, built for compressive stresses only, to prevent the structure from tipping forward.

All the stays and guys are fitted with turnbuckles so that stretch—due to temperature or loads—can be taken care of. The cross-yards are fitted with tracks on which the carriage supporting the athwartship moving cable travels. A self-oiling cableway carriage runs on the above cable and carries sheaves for hoisting rope. The field of operation is divided into two parts by the middle yard; each field has a separate trolley. The structure was calculated to withstand the working of four trolleys, each loaded with 5,000 lbs. weight, with a factor of safety of 8. The operating machinery is located in a house on the main mast, situated just below the cross-yard. The mast passes through the house, the steel floor of which is bracketed to the mast. The house was built large enough to take four hoisting machines if required, but two only were fitted and have been found sufficient. Each machine is operated by a 35 HP. continuous motor, 250-volt, having a speed of 550 r. p. m., geared so as to give 68 r. p. m. for the hauling and hoisting drums. The hoisting sling, or hook, can be lowered from its highest position to ground in 10 seconds. Maximum load can be hoisted in 30 seconds. Total transverse motion takes 30 seconds. Distance between yards covered in 30 seconds, and more than 100 tons of material have been handled daily.

The trolley has proved to be efficient in every way, and has fulfilled my highest hopes. The yards and stays have been used for other purposes also. Tackles have been made fast to same for hoisting weights, and small trolleys have been fitted to the fixed fore-and-aft stays.

This trolley is fed by an elevated track which runs from plate shop to ships, and by two locomotive cranes which carry weights from different shops and stock yard to ships on a double set of tracks which run under the ships.

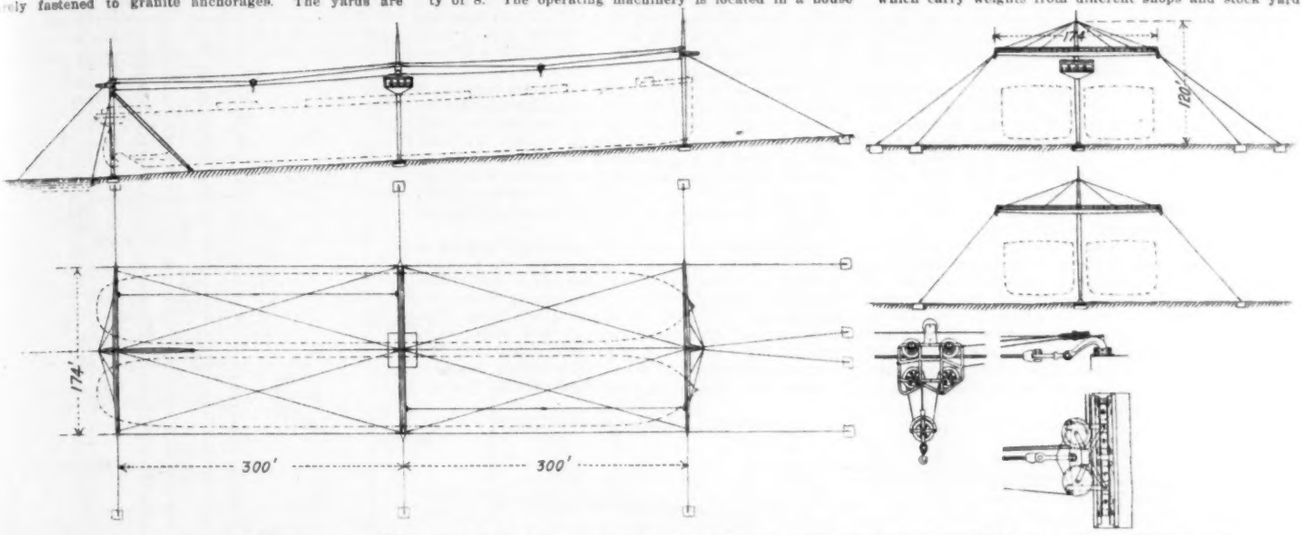


FIG. 1. DIAGRAM OF TRAVELING CABLE TROLLEY OVER SHIPBUILDING BERTHS, EASTERN SHIPBUILDING CO., NEW LONDON, CONN.

It was found before we started on these vessels, that pneumatic riveting had reached a stage more than experimental; we therefore installed a plant consisting of two compressors with a capacity of about 2,500 cu. ft. of free air per minute compressed to 100 lbs.

The preparation of the building berths for the vessels went on apace with the erection of the buildings. To have a sufficiently strong foundation to take the immense weight which will be superimposed thereon is of fundamental importance. The ground was rather uneven, but had an average declivity of one in twelve towards the river; this we cut down to five-eighths in twelve in way of launching slip. The ground was naturally strong, having considerable rock ledge underneath. Piles were driven, wherever permissible, and capped by bed logs on which the keel blocks were placed. The keel blocks had oak cap blocks laid to a declivity of ¼-in. per foot, sufficient space being left between bed log and keel at foremost block for riveting under bottom, this space increasing towards the after end. Very large bilge blocks were built under the vessel, having an area each of 128 sq. ft.—one placed amidships and one at a point 115 ft. each side of midships.

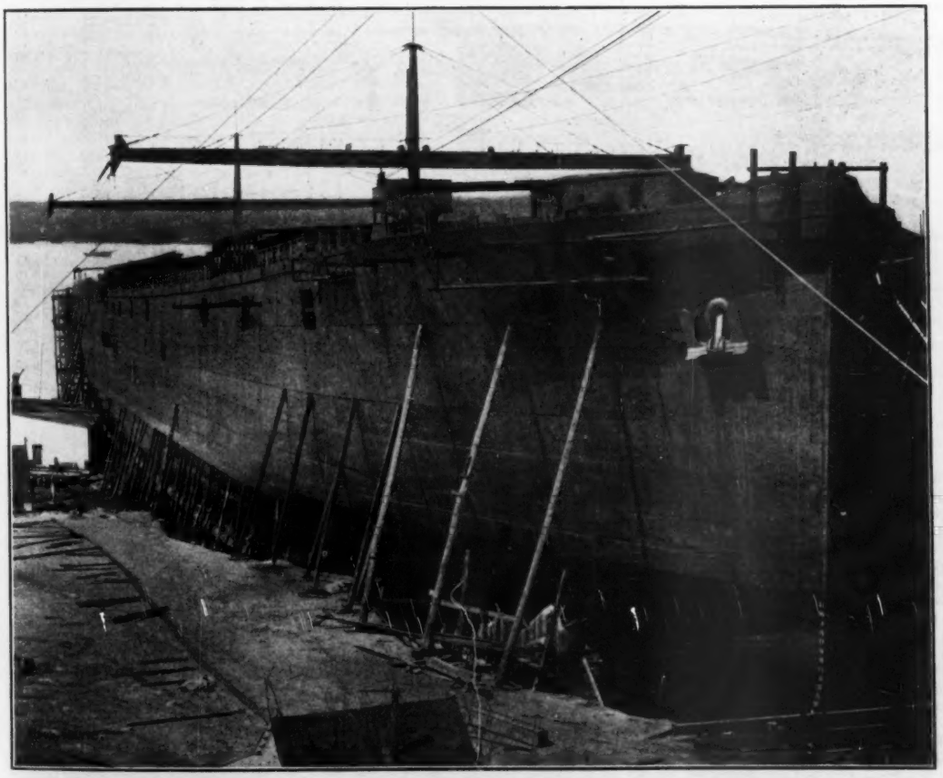


FIG. 2. STEAMSHIP MINNESOTA ON STOCKS BEFORE LAUNCHING. SHOWING TRAVELING CABLE TROLLEY.

We commenced building the vessel from the midship frame towards each end, the reasons for this being manifold. These vessels have the three lower decks perfectly level, i. e., without sheer and without camber; this allowed us to order the dead flat portion of the vessel—of which there is about 230 ft.—from the drawing of the midship section, without waiting on the mold loft to get correct plate edges, which would have been necessary if the decks had sheer.

The double bottom is 6 ft. deep, and is built on the cellular system. The longitudinals are all continuous. The third longitudinal from center line—as will be seen on plate of midship section—is water-tight, thus dividing the double bottom into three compartments longitudinally. The floor plates and longitudinals are lightened by manholes, which make the double bottom thoroughly accessible; the longitudinals are continuous through the bulkheads.

The keel plate is in two thicknesses, the inner being 1¼ ins. and the outer 2 ins. The rivets are 1¼ ins. diameter. The thickness of bottom shell plating is $^{17}/_{32}$-in., tank top $^{11}/_{32}$-in., under engines 1-in. to $^{12}/_{32}$-in., under boilers $^{13}/_{32}$-in., the whole making an immensely strong girder. This double bottom we built complete before erecting frames.

In the engine space, belt or web frames were fitted to the height of the lower deck, while the channel frame was fitted from this point to the upper deck. In the boiler space the alternate frames were webs. These heavy frames required considerable shoring, as the tendency of the weight was to make them sag and fall aft at the head. Changes in temperature caused a noticeable change in dimensions of this large structure.

The frames are spaced 30 ins., heel to heel, from fore peak bulkhead to aft peak bulkhead; in the peaks the spacing is 27 ins. From the fore peak bulkhead back to a point one-fifth the vessel's length from stem the frames in the bottom are doubled, and several strakes of shell plating in vicinity of three fifths length at each end just over turn of bilge have an additional row of rivets in their landings. This precaution has been found necessary in such large vessels, for, when running light in a heavy sea, pounding has produced slackness of rivets in this part of the structure.

The keel plate, towards the ends, conforms to shape of ship, and ends on the stem shoe piece (see Fig. 5). This shoe piece is of cast steel, and has webs to take floor plates, a longitudinal web to take center girder, and sides to take two rows of shell rivets. It extends around bow of stem, and is scarfed to latter by a 38-in. scarf. The stem is also a steel casting, and is rabbeted to take shell plating. The weight of stem and shoe piece is six tons. The stern castings for these vessels are of cast steel and made in six pieces, including the shaft struts. The stern frame rises from the keel abaft aft peak bulkhead, and is raised over tips of propellers, as shown in Fig. 3. The struts supporting propeller shaft are bolted to side of post. The after or rudder post carries six gudgeons. This is the narrowest part of the ship, and difficulty of riveting here was overcome by having flanges project aft from post, to which the ends of shell plating were riveted. The weight of this stern-post is 55 tons. The shell plating and frames are bossed out round the shafts so that the shaft can be got at as far back as aft peak or stuffing box bulkhead. Shell plates ending on the struts are increased in thickness, and are riveted thereto by treble and quadruple rows of rivets around the boss part of casting.

The longitudinal bulkhead in this vessel is a novel feature in a large merchantman. It extends from end to end of ship, from tank to main deck, thus dividing her into two parts. The cargo hatches are also in pairs, one in each hold, on each side of this bulkhead. The longitudinal bulkhead is 18 ins. off center, and directly over the starboard vertical keel. Forward of machinery space on tank top a tunnel is built, one side of which the longitudinal bulkhead forms, and the other side is built of plate, between tank and orlop deck. This tunnel extends through forward holds, and is water-tight, and entered by a water-tight door from boiler room. An escape is also provided at fore end leading to crew's quarters. All the ballast and bilge piping is led through this tunnel to the pumps in the engine room.

The Minnesota is divided transversely into 13 water-tight compartments by bulkheads. The peak bulkheads are water-tight from tank to upper deck, while the remainder are water-tight to main deck. The bulkheads at each end of boiler room are sloped away from boilers from 'ower deck upwards as shown (Fig. 4). This sloped part forms the bottom of the coal bunker, and assists the coal in gravitating to the coal chutes which lead to firing platform. This bulkhead is made water-tight at shell by staple angles round frames.

The upper and main decks are the only decks in hull of ship which have sheer and camber. The stringer plates on these decks are 1-in. thick amidships, to $^{11}/_{32}$-in. at ends. In way of all hatches, doublings are fitted to deck plating, as compensation for metal cut out; corner doublings are also fitted. The sheer strakes at main and upper decks are 1-in. thick for one-half length to $^{13}/_{32}$-in. at ends, and both are doubled by 1-in. plates for three-fifths vessel's length amidships. The thickness of upper sheer strake through doubling plate, stringer angle and outside butt-strap is $3^{3}/_{32}$ ins. The rivets in these sheer strakes are 1¼ ins. and 1⅛ ins. diameter, and were driven by pneumatic tools.

I cannot better illustrate the difficulties entailed in large ship construction than by making a comparison between the rivets driven in large and small vessels. Many places in the Minnesota and Dakota required two pneumatic reamers to keep ahead of one pneumatic riveter, whereas on some car floats building at these works (and these car floats are 318 ft. long), one reaming machine was able to keep ahead of seven pneumatic riveting machines.

The decks are all supported by box-shaped girders, as shown in midship section. These girders are bracketed to bulkheads by a heavy web plate which also stiffens bulkhead; between bulkheads wide spaced pillars are fitted as on profile; they are kept clear of hatches. This dispenses with all portable pillars, which is the usual practice. This system of pillars and girders was first used in ocean vessels by the Ocean Steamship Company. I believe that the Minnesota and Dakota are the first vessels, fitted in this manner, to be classed by Lloyds in this country.

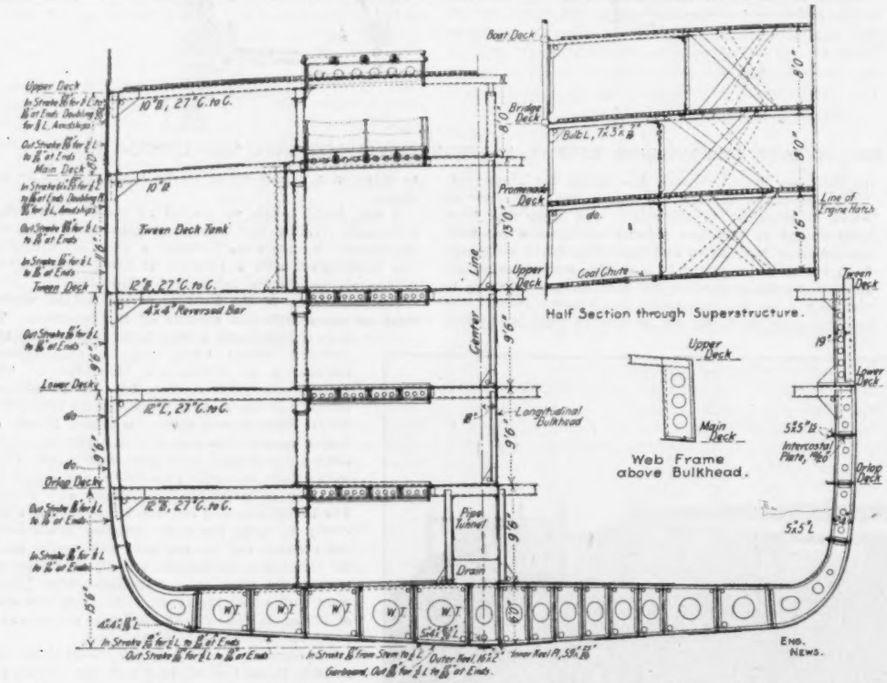


FIG. 3. MIDSHIP SECTION OF 21,000-TON STEAMSHIP MINNESOTA.

In the lower part of hold No. 3 a space is provided for carrying 1,635 tons of refrigerated cargo. This space is insulated with pumice where practicable, and cork is used elsewhere. In hold No. 5 the ship's provisions are stored. Rooms are provided for groceries, wines, vegetables, meats, milk, fish, specie, etc., in all occupying 324 tons space. The plant for refrigerating these holds is located in house on upper deck, and is very powerful, consisting of two 30-ton Linde marine ammonia compressors. This location is such that no damage can be done in event of ammonia gases escaping. In addition to the refrigeration of ship's consumable stores, the making of ice and the cooling of drinking water, this plant also takes care of 1,635 tons of frozen cargo.

The rooms for ship's stores, which require to be kept at varying temperatures, from 26° F. to 40° F., are cooled by rows of brine pipes in each room, whereas the holds are cooled by cold air, which is driven through ducts leading from the air cooler. The air coolers are located on the 'tween deck, immediately over the cold-storage hold, and are of an improved type, a means being provided for purifying the air as it passes through the cooler by a brine spray.

The whole refrigerating plant is arranged in duplicate, one compressor being able to take care of all cargo and stores, and again, if both compressors are running, one set of pumps is sufficient to circulate water for both cond- - - and circulate brine in both tanks. This precaution was considered necessary, as a stoppage through a breakdown or insufficient supply of condensing water, might ruin the cargo and entail a heavy loss. The ca-

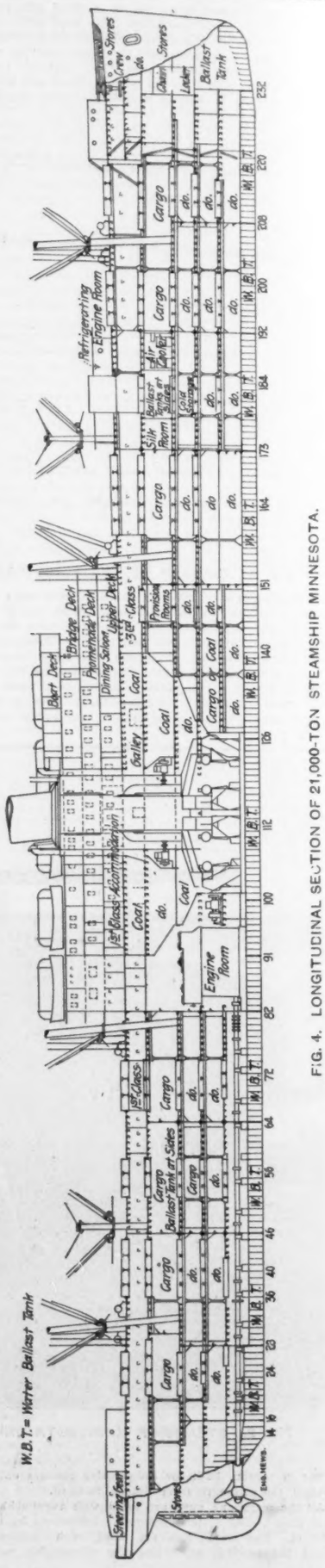


FIG. 4. LONGITUDINAL SECTION OF 21,000-TON STEAMSHIP MINNESOTA.

pacity of each set, making up this plant, is equal to the melting of 30 tons of ice every twenty-four hours.

As shippers of a frozen cargo are very exacting as to maintaining a uniform temperature throughout entire voyage, it is necessary to take every precaution; the insulation of the holds, therefore, is a most important factor in obtaining good results. The holds for frozen cargo in this ship are insulated wherever practicable with calcined sterilize pumice (see Fig. 8). The pumice is generally 6 ins. thick, filled in between walls made of two thicknesses of wood, between which a layer of paper is fitted. The walls of rooms which divide up space for ship's provisions are built with cork, wood, paper, and air space. We have obtained a feature in our insulation which has only recently come into prominence in ships engaged in frozen trade, and this is the ventilation of the bilges, space between back of insulation and shell being used for this purpose.

Part of hold No. 3 is set apart for carrying silk, and constructed to be thoroughly rat proof.

The anchor and forward warping appliances consist of a specially heavy Hyde windlass, with two vertical shafts driven by worm gearing direct from a worm located on the crank shaft of the engines, 18 and 18 ins. by 14 ins., without the intervention of counter-shafts or bevel gears. Each shaft carries on its upper end above upper deck a wildcat with locking gear complete. The arrangement is such that the wildcats can be operated together or independently of each other. Each wildcat is fitted with a positive locking device worked by raised cams on the periphery of the locking rim, and slotted block keys operated by means of lever. The entire operation of locking or unlocking the wildcat is accomplished by one motion of the lever through an angle not exceeding 60°. There are two warping heads, each about 26 ins. diameter of barrel, which are capable of taking in rope at the approximate rate of 12 fathoms per minute, and to operate together or independently of each other. The engines are reversed by a change valve so arranged as to be operated from both the upper and forecastle decks. Two extra strong chain stoppers of the naval type are fitted to each windlass, and the devil's claws for securing the chains are fitted to the bed plate.

The windlass, with 150 lbs. of steam at boilers, will raise two 8½-ton anchors with 60 fathoms of $3^{3}/_{16}$-in. chain, at the rate of 5 fathoms per minute. The weight of the chain cable is over 80 tons, and the whole equipment—anchors, cables, and wire—weighs about 130 tons. The anchors are stockless. They and the chains are the heaviest ever made in this country. The hawse pipes are steel castings, the ship being stiffened internally in way of same. A heavy wrought-iron anchor crane is fitted on forecastle head.

The steering gear, built by Williamson Bros'. Co., is located in a house aft on upper deck. Steam and electric steering gears are installed; the steam being used for emergency and the electric for ordinary service. Both gears are directly attached to the quadrant. The steering motor is rated at 75 HP., and is capable of withstanding a momentary overload of 100% (Fig. 6). In the main engine room, close to the dynamo room on the lower deck, is placed a motor-driven generator, with an exciter attached to the same shaft. The fields of the exciter are in circuit with the balancing wire, connecting the steering resistance with the rudder resistance. By suitable arrangement and proportions of generator and exciter we are able to multiply the effect of small current flowing in the balancing wire and obtain sufficient power to drive the rudder motor. Steering columns are placed on both the upper and lower navigating bridges.

The immense rudder which these gears operate weighs 38.5 tons, and is carried by a roller bearing on upper deck. The rudder is a steel casting in five sections, including the stock. The stock is 14½ ins. diameter, and connected to head of rudder by a horizontal coupling. This coupling is keyed and bolted by six bolts (see Fig. 5.)

As already stated, the hatches are fitted in pairs, two to each hold, one on port and one on starboard side of longitudinal bulkhead, making 18 hatches in all.

These vessels are fitted with four pole masts, arranged to carry cargo booms for working cargo, and four derrick posts. The fore mast and jigger mast each carry 8 cargo booms; the mainmast and mizzen mast each carry 4 cargo booms, and the derrick posts each carry 2 cargo booms, thus making 32 cargo booms. The masts, derricks, and booms are all built of steel. This arrangement gives two cargo booms to each cargo hatch. One boom is guyed over the hatch, while the other reaches overboard to wharf or lighter, and guyed in that position. The hoisting wire from each boom is hooked to piece of cargo to be lifted, the other end being led to the winch drum. A winch is supplied for each boom, two winches being fitted close together and controlled by one man; the winches are fitted with drums as well as gypsy ends. The hoisting wire being made fast to drum enables the man to hoist with one winch and pull overboard with other; having no free end of rope to look after, a second man is not required.

The winches, furnished by the Lidgerwood Manufacturing Co., are all electrically operated. The controllers and brakes are situated close to hatch, so that operator can look down into hold and attend winches simultaneously. These winches vary in capacity from 20 HP. to 29 HP. Rope speeds from 170 to 150 ft. per min.

In addition to the ordinary cargo booms two heavy booms are fitted, one at mainmast and one at jigger mast, for lifting weights of 50 and 30 tons, respectively. These booms are built of steel and have ball castings on lower end which ship into cast-iron sockets bolted to deck in front of the masts mentioned. Heavier winches are fitted in proximity to these heavy booms, the horsepower being 35 and rope speed 130 ft. per min.

There are six direct-connected Westinghouse generators, each 75 KW., driven by a Westinghouse compound vertical engine. Each generator is a six-pole machine, furnishing direct current at 110 volts when making 300 r. p. m. The electric light installation consists of about 1,300 lights distributed throughout the vessel, and a powerful 24-in. searchlight of the General Electric make placed on the forward lookout bridge. This light can be operated from the navigating bridge by an electric or hand gear. The port, starboard and masthead lights are electric, and a tell-tale is fitted in chart house which indicates if lights are burning or not. An indicator also shows at what angle the rudder is standing. For signalling in fog an electrically controlled steam whistle is fitted, which is automatically sounded at the desired interval by a clock control, and can also be controlled by hand.

The wiring is on the three-wire system, and several switchboards are conveniently placed throughout the vessel, lights taking 110 volts, power and heating 220 volts. All staterooms, bathrooms, and officers' quarters will be heated by electricity, in addition to the hot-air system. Motor drive is used for the refrigerating engines, cargo winches, ventilating fans, steering gear, laundry machinery, coal conveyor, provision hoist, and after warping capstans.

The vessel being propelled by twin screws, there are two sets of three-cylinder, vertical triple-expansion engines of the direct-acting, surface-condensing type, with cylinders 29, 51 and 89 ins. by 57 ins. stroke, designed to develop about 5,000 I. HP. each at 78 revolutions, with a steam pressure at engine of 230 lbs. per sq. in. These engines were built by The Midvale Steel Company.

The bed plate for each engine is composed of three castings bolted together, providing six bearings for the crank shaft. It is of the box type, and extends under the whole of the engines, carrying the housings and columns. The main bearings are 18 ins. long, with caps of cast steel,

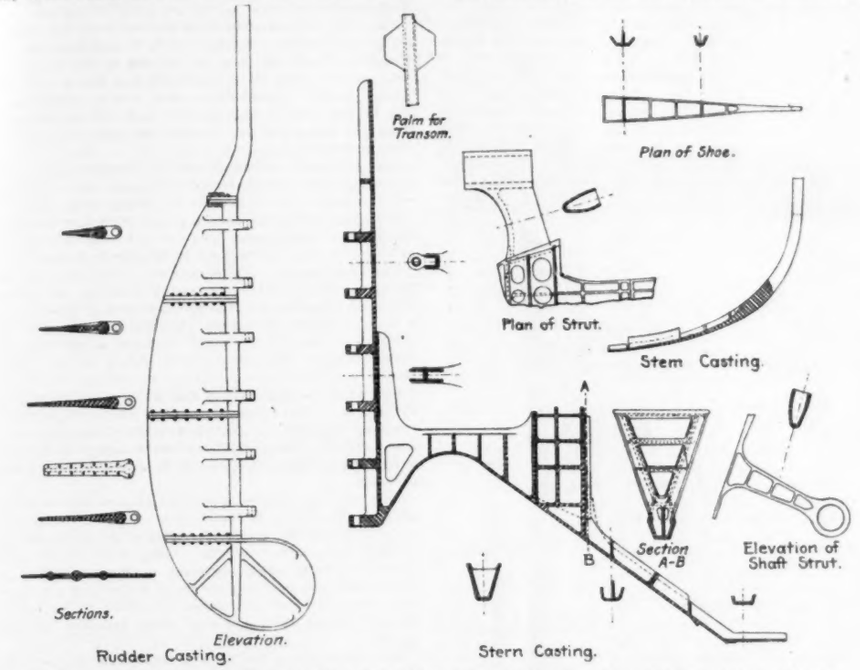


FIG. 5. STEM, STERN AND RUDDER CASTINGS OF STEAMSHIPS MINNESOTA AND DAKOTA.

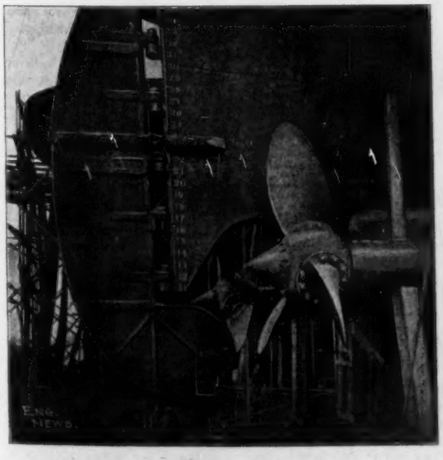


Fig. 7. Rudder and Propellers of Minnesota.

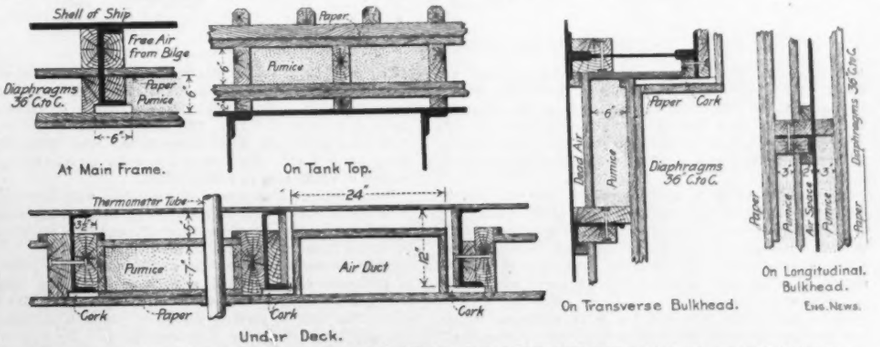
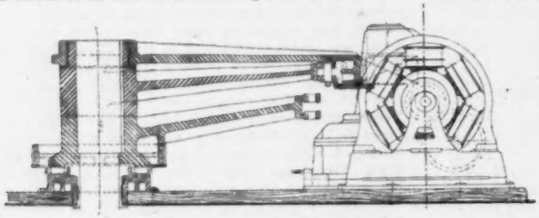


FIG. 8. SOME DETAILS OF THE INSULATION OF REFRIGERATED HOLDS IN STEAMSHIP MINNESOTA.

lined with Parson's white metal; the bottom box of cast steel with a brass bush lined with Parson's white metal ⅝-in. thick, and water circulation is provided through top and bottom boxes.

The high-pressure cylinder has one piston valve 17 ins. diameter at top and 16½ ins. at bottom. The middle pressure cylinder has one piston valve 32 ins. in diameter, and the low-pressure cylinder one double-ported slide valve 95 ins. wide by 50 ins. long. The piston valves take steam on the inside. All valves have a common stroke of 10 ins. when reversing link is in its normal position. The middle and low-pressure valves are fitted with Joy's assistant cylinders. The low-pressure steam chest is a separate casting, and the low-pressure cylinder has a false face of hard cast-iron bolted to cylinder face, on which the double-ported slide valve works. A circular relief frame is fitted to the back of the L. P. valve.



Sectional Elevation of Motor Drive.

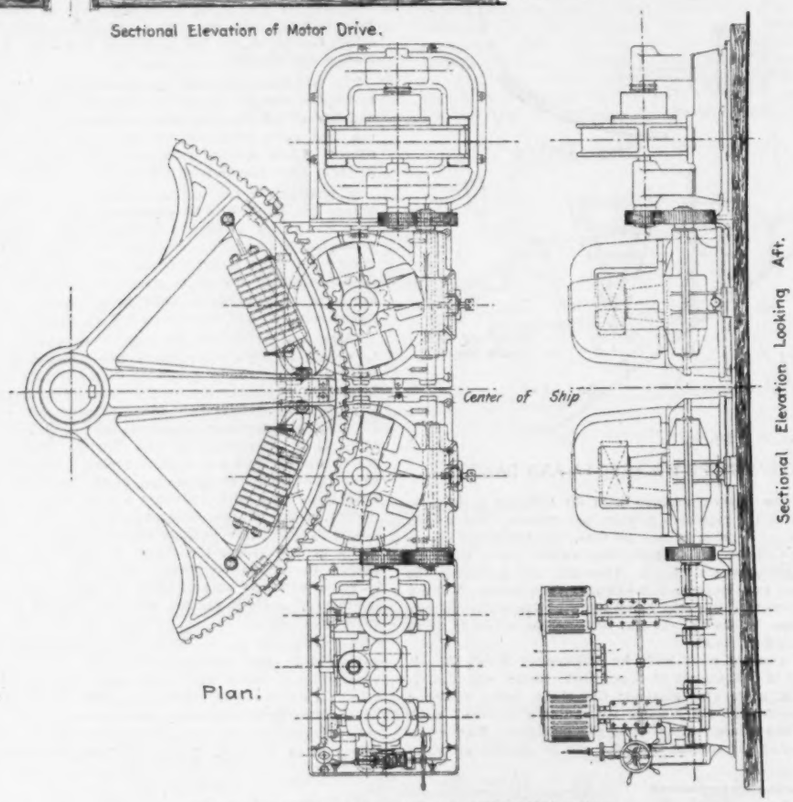


FIG. 6. ELECTRIC AND STEAM STEERING GEAR.

The throttle valve is of the butterfly type, 11 ins. in diameter, bolted to under side of stop valve. Said valve is automatically controlled by an Aspinall governor, which is connected on a special lever worked from the low pressure crosshead. The governor gear can be disconnected when in port, and the throttle valve worked directly by hand lever.

Each engine room is provided with an oil pump, which has suction connected to crank pits, thrust block and oil separator, and discharges into an oil filter located at the main deck. After the oil has been cleaned in the filters it can be used over again, and drained into the oil-service tanks below. The oiling is by wick feed from brass oil boxes on the cylinders for main moving parts, separate boxes being fitted for each main bearing and eccentric; while eccentric rod pins and link reversing bearings, etc., have separate boxes of locomotive type.

All shafts, except crank webs, are of high grade carbon steel, oil tempered; tensile strength 75,000 to 85,000 lbs.; elastic limit not less than 45,000 lbs.; elongation 24% in 2 ins. Crank webs, tensile strength 58,000 to 65,000 lbs.; elastic limit not less than 35,000 lbs.; elongation 25% in 2 ins., annealed after forging. The crank shaft is in three duplicate and interchangeable pieces, and the sequence of cranks is as usual, namely: high-pressure, middle pressure and low pressure. Each section is 10 ft. 5½ ins. over all; shafts and pins are 18 ins. in diameter with 8-in. axial hole.

The thrust shafts are 18¼ ins. diameter by 14 ft. 5½ ins. long, with 9 collars 2½ ins. thick, and a space of 5½ ins. between collars, with axial hole 8 ins. in diameter; outside diameter of collars is 27⅝ ins. There are six intermediate shafts 17 ins. diameter by 22 ft. 6 ins. long, each supported on two spring bearings; and two Verity coupling shafts, 17 ins. diameter by 7 ft. 7½ ins. long on each line of shafting, with axial hole 7¾ ins. in diameter, and each supported on a spring bearing.

The tail shafts are 19 ins. in diameter by 36 ft. 10¾ ins. long, and with 8¼-in. axial hole, reduced at propeller end to 5 ins. diameter for a distance of about 9 ft. The holes are fitted with water-tight plugs, where necessary, to prevent water entering ship when shafts are disconnected or broken. Each tail shaft is covered with composition water-tight casing, made in sections, shrunk and pinned on.

The stern tubes are of cast iron, cast in two pieces and riveted together; length over all is 27 ft. 3¼ ins. Stern bushes are of composition, and the length of lignum-vitae strips is 6 ft. 8 ins. The thrust blocks are of cast iron with nine cast steel horse-shoes, lined with Parson's white brass. Each shoe has water circulation and collars of shaft also run in oil bath.

The propellers have bosses of cast steel, and three cast steel blades which will be replaced by manganese bronze blades later. The diameter is 20 ft. and the pitch can be varied from 21 ft. 6 ins. to 23 ft. 6 ins.

There is one double reversing turning engine, located in port engine room, fitted with clutches, so that either of the main engines can be connected or disconnected at will. The size of turning engine is 6 and 6 ins. by 6 ins. and is reversible by a change valve.

There are on each vessel four evaporators and two distillers, with their accessories. The evaporators have a combined capacity of about 28,000 gallons of fresh water per 24 hours.

The sanitary arrangement is on the pressure system, and each of the sanitary pumps has an automatic governor, regulating the water pressure throughout the vessel. There is a hot, as well as a cold, water service, both for fresh and salt water, with separate pumps and distributing pipes.

There are sixteen Niclausse water-tube boilers, built by the Stirling Co., containing 272 elements, with 24 3¼-in. tubes in each element, constructed for a steam pressure of 250 lbs. per sq. in. and arranged fore and aft with two fire rooms on each side. The 272 elements contain 40,614.8 sq. ft. of heating surface, and 1,080.8 sq. ft. of grate surface.

The boiler uptakes lead into four rectangular uptakes which lead into one rectangular stack about 14 × 16 ft., which forms the support for the smokestack, elliptical in shape. The inside stack is 16 ft. by 13 ft. 3 ins., and the outside stack 19 ft. by 16 ft. 3 ins. The height of stack above base line is 134 ft. 6 ins.; above grate 124 ft. 6 ins.; above bridge deck 54 ft. 6 ins.

A system of induced draught is installed in connection with the main boilers, there being four 9-ft. fans, and each fan is direct connected to a 9 and 15 in. by 9 in. Westinghouse engine.

The four after starboard boilers on steamship Dakota will be fitted with Duluth stokers, to determine the advisability of putting them in the rest of the boilers in both vessels, which are so arranged that said stokers can be put in with a slight alteration to boilers. Boilers having Duluth stokers will be fitted with ash conveyors at the back, which will be driven by the same engines driving the stokers.

Beside the old method of hoisting the ashes out of the fire rooms up through ventilators, by a steam hoist, of which there is one for each fire room, there is also a See's ash ejector fitted in each of the fire rooms, by which the ashes are discharged from the fire room in a stream of water through pipes leading directly overboard.

The great day in all shipyards is a launching day, the importance of the event increasing with the size of the vessel to be launched. The problem we had was to drop a mass weighing more than 11,000 long tons (or 12,320 short tons) through a vertical height of about 30 ft., in such a manner that the structure should not be unduly stressed.

The mean rise and fall of tide at New London is only about 2 ft. 7 ins. Our groundways were built at ⅝-in. per foot declivity, and had to be carried out into water about 200 ft. The groundways were laid without camber, with an incant of ½-in. per ft. and in a fore-and-aft direction.

Two stout dog shores were fitted to port and starboard sliding ways to hold vessel after she was thoroughly wedged up, but the means of releasing the vessel was by cutting an extension of the sliding ways which was bolted to ground ways. In event of ship not starting to move when oak was cut, hydraulic jacks were placed on each way at end of fore poppet to impart motion, and a forward sliding block was built under fore foot for same purpose.

The vessel* had a preliminary wedging up on the evening before launch, and at 9 a. m. of launching day she was again wedged up and all keel blocks split and cleared away. The last supports to be removed were the bilge blocks, which were somewhat troublesome to get out, the forward starboard block giving a great deal of trouble, as all of the upper wedges had to be split to pieces; this delayed the launching nearly two hours. After the bilge block was cleared away, the dog shores were dropped and the cutting of the oak holding piece commenced. When the saws had cut to within ¾-in. of whole thickness, the weight of vessel acting down the ways told, and she tore the rest asunder. The sectional area of oak not sawn was 81 sq. ins. This roughly represents a force down the way of 405 tons; therefore, the coefficient of friction was very small. The total launching weight of the vessel was about 11,000 tons.

The temperature on launching day averaged about 50°. The method of lubricating ways was as follows. The lubricant used was principally tallow and lard oil. The tallow and oil were boiled together in proportion of 84% tallow to 16% oil. The groundways were rubbed with hard soap to fill up all pores in wood. The tallow was then applied hot and, when cold, strips of soft soap mixed with softened flaxseed were laid across ways on top of tallow. Prior to letting down sliding ways, hot oil and tallow was poured over the groundways, the under side of sliding ways being coated with ¼-in. of tallow. The lubricant on water-covered part of ways was weighted with graphite. Total weight of lubricating material was 20,000 lbs.

The length of ways under water was difficult to keep well lubricated. An oil reservoir placed on deck of ship with pipe connection leading through end of sliding ways was fitted to lubricate in front of ways as they slid down. The ship herself was strengthened inside by shoring, etc., in way of fore poppets, also in engine and boiler spaces. The stockless anchors of the ship were in position in the hawse pipes, and cable laid out on deck in such a manner as to cause a resistance when paying out. Immediately after the ship was fully afloat, the anchors were dropped and the vessel brought to rest.

On examination of the ways after launch no deflection was perceptible. The point of commencement of pressure on fore poppet was easily noticed by the lubricant being scraped off, beginning at point where the ways were increased in width to take this pressure.

The "Minnesota" and "Dakota" were designed primarily as cargo vessels, with accommodations for a few first and second-class passengers. They will be engaged on long voyages and will have a speed of 13½ to 14 knots natural draught, and, when forced, a speed of 15 knots

*This refers to the "Minnesota," which was launched on April 16, 1903. The "Dakota," her sister ship, was launched on Feb. 6, 1904.

may be attained. The passenger traffic on this class of vessel in Pacific trade has still to be developed, and the owners have, from time to time, added to the passenger accommodations of the vessels. An extra deck-house was erected for first-class passengers. We have accommodation for 253 first-class passengers, 68 intermediate, and space for 1,300 troops or 2,400 steerage passengers. The beds have not been fitted for the latter, but lavatories are all equipped for their use.

The passenger and crew space is ventilated mechanically in addition to usual ventilation. Fresh air is supplied into the passages, and the vitiated air is exhausted direct from the rooms. In all large public rooms the exhaust is in the ceiling, and supply comes in at side. The galley has an exhausting system with natural supply. The engine room has a supply system with natural exhaust. Dynamo room has exhaust and supply. The provision spaces are ventilated mechanically, also. The fresh air supplied to passengers is cleansed and heated or cooled by passing over coils of pipe for that purpose. In addition to this the first-class staterooms have electric heaters in each stateroom.

The principal features in the design of the "Minnesota" and "Dakota" are the proportions of depth and beam to length; a longitudinal system of framing in the double bottom; a bulkhead dividing the ship longitudinally; straight lower decks; high 'tween decks; the pipe tunnel; girders under the floor-beams, with wide-spaced pillars; double hatches; a partially-balanced rudder; two 'tween deck ballast tanks; and the sloping bottom of the coal bunkers.

The features in the equipment are the installation of water-tube boilers, mechanical stokers, electric winches, electric steering gear, large number of cargo booms, laundry equipment, refrigerating engine room on upper deck, type of windlass, electric heating of cabins, the ventilating system, and Clayton gas fire-extinguishing system.

Bottom of keel to upper navigating bridge	88 ft. 3¾ ins.
Total water ballast	5,072 tons.
Total coal capacity with reserve bunker	6,195 "
Total cargo capacity, excluding reserve bunker, about	30,000 "
Total stores	250 "
First-class passengers	253
Intermediate class passengers	68
Steerage passengers	1,300 to 2,400
Crew	250

The "Minnesota" is just three times the weight of the modern Pacific freighter. Everything about her is much larger than anything the workmen in this country have been accustomed to handle. The long, heavy beams, frames, plates, castings, the heavy riveting and great heights at which the men were required to work, all seemed to influence them in a manner detrimental to rapid progress. We had men whose ability to accomplish smaller work was known, but when engaged here could not take hold of a piece of work without assistance. This was noticeable on launching day, as many of the men, unaccustomed to such work, were very nervous and somewhat afraid.

The principal dimensions of the "Minnesota" are as follows:

Length over all, about	630 ft.
Beam, extreme	73 ft. 6 ins.
Depth bottom of keel to upper deck at center	50 ft. 1 in.
Upper deck to promenade deck	8 ft. 6 ins.
Promenade deck to bridge deck	8 ft. 0 ins.
Bridge deck to boat deck	8 ft. 0 ins.
Boat deck to captain's bridge	7 ft. 8 ins.

The pioneer in all undertakings does not make the same apparent headway as those who come after him. We have been the pioneers in the construction of merchant steamers of over 20,000 tons in this country, and in the contracts which we placed with outside firms for castings, ship fittings, etc., were met on every hand by: "We have not been accustomed to such heavy work, and will require to consider it on entirely new lines."

TIMBER DAM AT THE OUTLET OF CHESUNCOOK LAKE, PENOBSCOT RIVER.

By J. W. Tower,* Assoc. M. Am. Soc. C. E.

A dam of considerable importance has recently been constructed by the West Branch Driving & Reservoir Dam Co., at the outlet of the Chesuncook Lake, the largest natural lake included in the great network of lakes tributary to the celebrated West Branch of the Penobscot River.

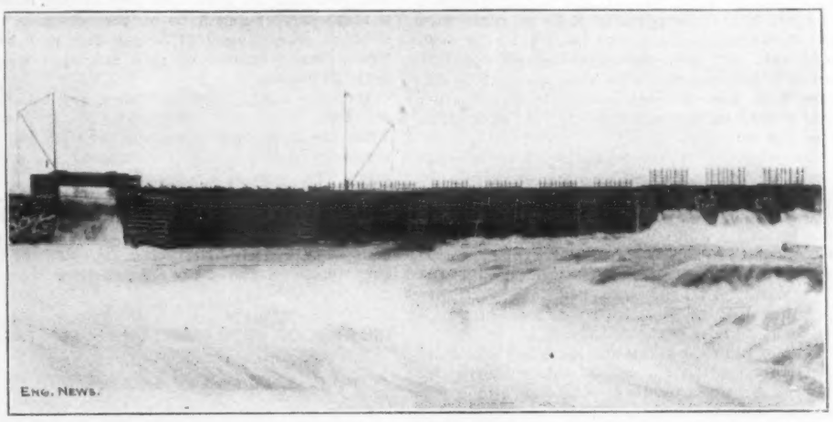


FIG. 1. CHESUNCOOK LAKE TIMBER DAM, SHOWING A 10-FT. HEAD OF WATER PASSING THROUGH LOG SLUICES.

The large pulp and paper mills of the Great Northern Paper Co. are located at Millinocket, Me., about 35 miles further down the West Branch. These mills have a capacity of some 300 tons of finished news paper per day and for power purposes require a continuous flow of nearly 3,000 cu. ft. of water per sec. The paper company does not have exclusive control of the water flow, owing to the fact that each year about 40,000,000 ft. of logs must be driven past its mills to points around Bangor, 85 miles below. This fact caused the formation of the first-named company for log driving and water storage purposes. The company is composed almost entirely of stockholders of the Great Northern Paper Co.

A small dam was built at the present site in 1840 to assist in log driving; and this was increased in length and height from time to time, as necessity required, until the last two seasons, when it has held the lake at Elev. 927, sea level datum.

The new dam (Fig. 1) is a timber structure 1,500 ft. long, built to Elev. 933, or 6 ft. higher than the old dam, and floods an area of about 33.05 sq. miles. The gate portion is 50 ft. wide on the bottom, and the wings are 36 ft. wide. The bottom upon which the cribs were sunk is very rough, and rather a shaley ledge, the water

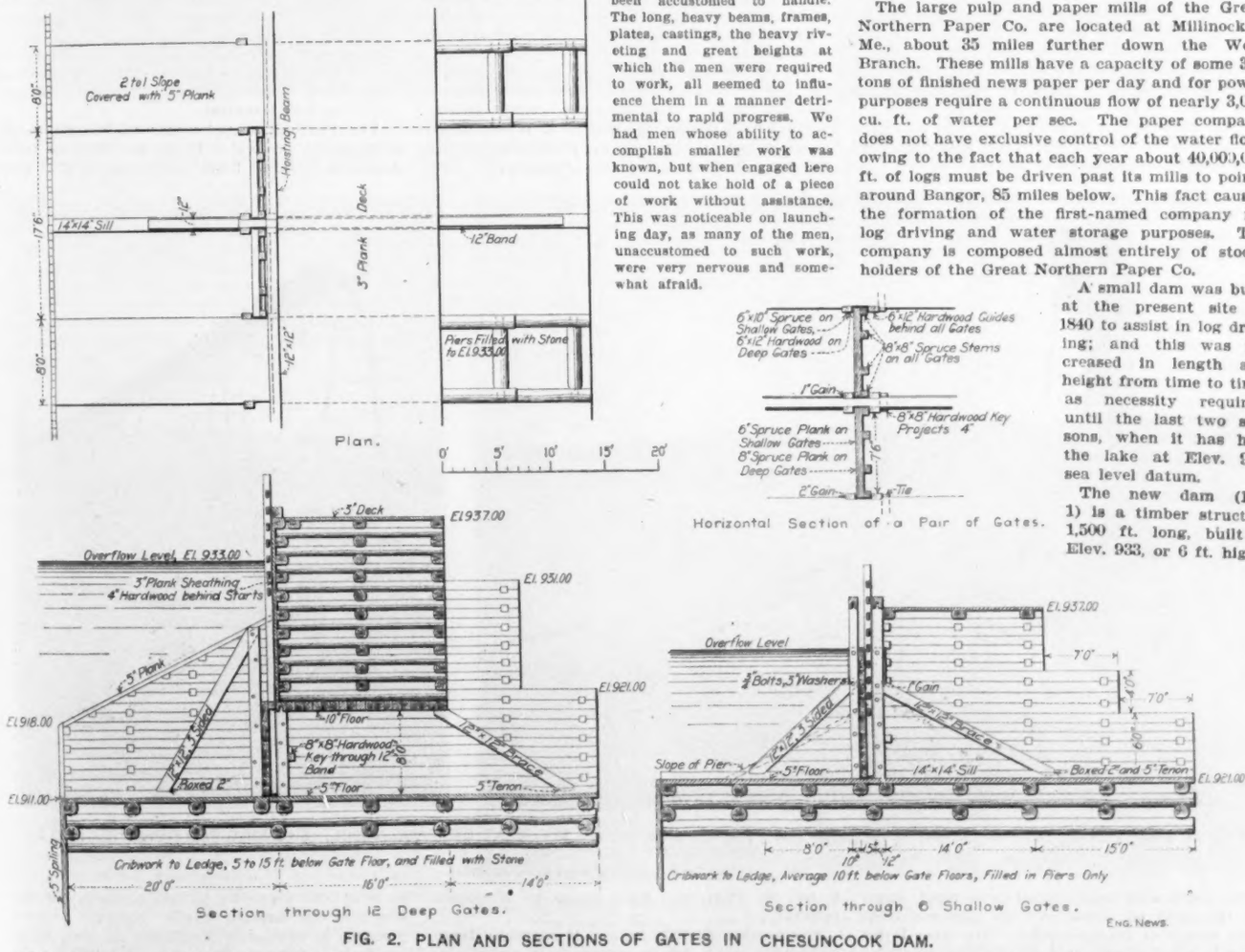


FIG. 2. PLAN AND SECTIONS OF GATES IN CHESUNCOOK DAM.

*Principal Assistant Engineer, West Branch Driving & Reservoir Dam Co., Millinocket, Me.

being from 5 to 15 ft. deep. The deep gates (Fig. 2) were placed so their floors would be as near the natural surface of the flowing water as possible, and 2 ft. lower than those of the old dam. Six pair of 8 × 8-ft. gates with bottoms at Elev. 911 were put in, above which a floor of 10-in. timber was placed, and cribwork carried up to the top as though there were no gates. Adjoining and at Elev. 921, three pairs (Fig. 2) of gates were placed, which open clear to the top in the ordinary way. All are slot-stemmed gates, raised by means of levers across a hoisting beam. The crib piers, 8 ft. wide between each pair of gates, are filled solidly to high water level with rock taken from the river bed.

The wings were but partially filled at points where conditions seemed to make it advisable. A slope of 2 to 1 on the up-stream face was maintained throughout; the down-stream lines were kept straight, while the toe spiling was drawn in toward the shore ends of the wings, to conform to the rising ledge. Wherever possible, the width was kept 30 ft., and spiled down vertically from Elev. 918. A 25-ft. log sluice passes through one wing, its floor being at Elev. 924.

Much of the rock filling and graveling was done from rafts, as the surface of the water in the lake raised; this proved a very easy and satisfactory method.

1,200,000 ft. of hemlock and spruce logs were used, which had to be cut and hauled from the surrounding forest. All timber was barked before laying, then notched, and finally fastened together with ¾-in. and ⅞-in. iron drift pins. For sawing this large amount of timber a complete saw-mill was required, which was brought to the site as early in the winter as the ice was strong enough to permit crossing with such a weight. Without this mill it would have been almost impossible to execute a work of this size within the length of time that was possible, before the spring high water. A steam drill was also used for getting ballast and with three steam derricks completed the machinery outfit.

The work was handicapped in several ways, not the least of which was its distance from usual means of transportation. The dam is located in what is exploited as the "Heart of the Big Game Country of Maine," and is inaccessible by teams, except over snow roads during the "toting" season of winter. All supplies had to be hauled 42 miles from Greenville Junction, the nearest railroad station. At no other season can heavy goods like machinery and iron be brought in, although provisions may be boated by way of Moosehead Lake, a distance of 80 miles. Much trouble was also experienced in getting suitable timber of sufficient quantities within hauling distance. Long periods of intense cold were experienced, — 30° F., with high winds, being common, yet no time was lost on account of the cold weather. All the work was done by day laborers, a large camp being built by the company. The average wages were $1.75 per day and board. The average number of men employed was 75, with 24 horses.

Building camps, cutting timber, and other preparatory work was commenced in September, 1903; the first cribs were sunk on Nov. 18. The structure was practically completed six months later. The cost will not exceed $60,000.

This dam was designed by Mr. H. S. Ferguson, M. Am. Soc. C. E., Chief Engineer of the Great Northern Paper Co. Mr. E. W. Prouty was resident engineer, with Mr. Percy Johnston, of Bangor, Me., in charge of the construction.

THE TORNADO OF AUGUST 20, 1904, AT ST. PAUL, MINN.

By C. A. P. Turner,* M. Am. Soc. C. E.

A few minutes before 9 p. m., on Saturday, Aug. 20, 1904 a violent storm struck the cities of Minneapolis and St. Paul, on the eastern border of Minnesota, and their immediate vicinity. The storm did a great amount of money damage, and about a score of persons lost their lives. The effects produced show it to have been a true tornado. The very great forces exerted by storms of this character give them a peculiar interest to the engineer.

The storm was remarkable among tornadoes for the great area covered and the widespread damage done. Originating in South Dakota, where severe damage is reported at Willow Lakes, Summit, and other places, the Minnesota towns of Glencoe, Waconia, Hopkins, Minneapolis, Stillwater, St. Paul, and some towns in Wisconsin, suffered.

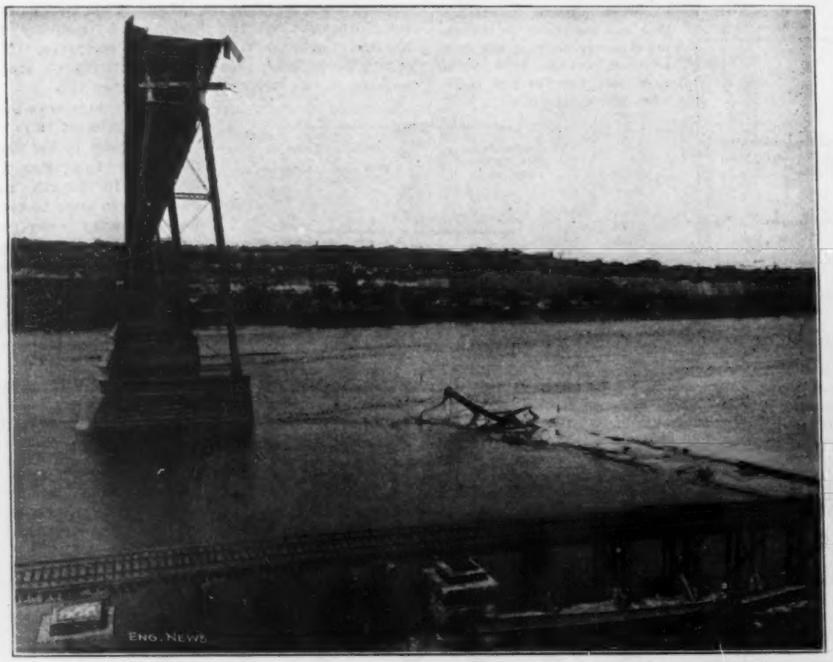
The number slightly injured is naturally large, while the death list is astonishingly small. At Waconia a funnel-shaped cloud was reported, which destroyed residences and everything in its path; one man was blown seven blocks, escaping uninjured, and in numbers of instances persons escaped with a few insignificant scratches, though the buildings in which they had been were reduced to kindling wood.

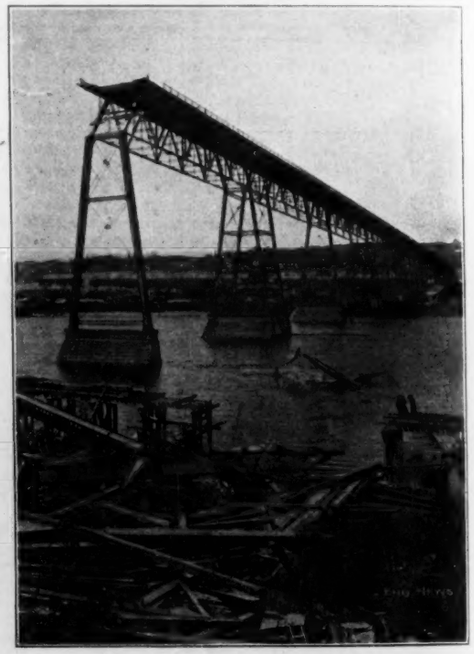
The afternoon before the storm was hot and sultry. Evidences of an approaching thunder storm appeared between 5 and 6 p. m., and a heavy storm commenced before 7. The wind as the storm progressed (in the vicinity of the writer's residence on the Lake of Isles Boulevard, Minneapolis), culminating in a very severe gust lasting eight or ten minutes. During this time rain and hail seemed to be driving horizontally, while the lightning enabled the observer to note the breaking of limbs and uprooting of trees. As the wind in his immediate vicinity seemed to vary but little in its general direction, the writer was inclined to regard the storm more as a severe gale, until he had noted the damage to buildings and property from 800 to 1,000 ft. on either side.

Following the track of the storm westward, the severest damage seemed to be confined to narrow strips, the condition of some of the broken trees indicating clearly that they were twisted. As these strips of damage appeared to be 1,000 to 4,000 ft. apart, it would seem probable that there were several small twisters traveling with this larger storm, of the nature of eddy currents formed between the mass of air revolving at high velocity about the true storm center and the more quiescent air outside.

During the storm, according to the Minneapolis "Journal," the temperature dropped 10°, the barometer dropped from 28.40 to 28.25, then rose again to 28.80 ins. The maximum recorded wind velocity at Minneapolis was 110 miles per hour, while St. Paul claims 180 miles per hour as the highest velocity recorded just as the anemometer was blown over. The accuracy of the recording instrument, however, may be questioned for such velocities and pressures.

The features of the storm of interest to the engineering profession lie in its effect on buildings and bridges. Such application of wind loads as is usually presented in text-books is far from adequate to explain these effects. Negative pressure or suction is exhibited, as well as exceedingly great positive pressure. If, for example, the storm can reduce the atmospheric pressure over an exterior surface, then the air under normal pressure on the interior will tend to force the surface out; thus, in a number of cases, the leeward surface of a roof, together with the section of a side of a building, was found ripped





FIGS. 1 AND 2. TWO VIEWS OF SMITH AVE. BRIDGE OVER MISSISSIPPI RIVER AT ST. PAUL, MINN., SHOWING PORTION WRECKED BY TORNADO OF AUG. 20, 1904.

Both views are from southend (west bank of river).

*Consulting Engineer, 816 Phoenix Bldg., Minneapolis, Minn.

off, leaving the windward surface sticking up in the air.

The tearing away of the floor of the Tenth Avenue Bridge, Minneapolis (Fig. 5), is an interesting case of upward pressure. It is to be noted that this old-fashioned iron frame, with its counters in every panel and its expansion joints rusted tight, though repeatedly condemned as unsafe still remains intact, lacking only a floor.

Figs. 1 to 4, views of the so-called High Bridge, crossing the Mississippi at Smith Avenue, St. Paul, are of interest, in view of the fact that the wreck of a well-braced steel structure by wind is extremely rare. The secret of the wreck appears to lie in the careful provision made for temperature stresses at the expense of lateral stiffness and vertical resistance to the uplifting action of wind. The lesson should be the more valuable in view of the fact that the provision made was in accord with general practice.

The views shown herewith may be supplemented by the remark that the business district suffered mainly by the crushing in of windows, show-windows and skylights. In the Guarantee Bldg., Minneapolis, a large skylight, supported by a steel truss roof over the interior court, was crushed in and fell twelve stories, but injured no one. The skylight was made of heavy ribbed glass. The Pioneer Press Bldg., St. Paul, a 13-story office building, had many windows blown in, mainly in the upper stories.

Cornices, parapets, etc., were blown down into the streets. Telephone and trolley wires were badly mixed up. On the day after the storm, the street-railway service in St. Paul and Minneapolis was still in bad shape, the trolley-wire system having been wrecked at many points. The railways were little damaged.

The above description, with the accompanying views (Figs. 1 to 14), showing scenes in the damaged districts of St. Paul and Minneapolis, will suffice to give a general idea of the extent and violence of the tornado. The concentrated and erratic nature of the severest gusts is particularly well illustrated in the views Figs. 8 and 13. Some additional data on the two bridges affected by the storm may be appropriate.

The Smith Avenue bridge over the Mississippi River in St. Paul, Figs. 1 to 4, was built in 1887-1888, according to general plans prepared by the city's engineering department. Detail designs and drawings were made by the contractor, Mr. C. L. Strobel. The bridge was erected by Mr. Horace E. Horton, of Chicago, Ill. The material is wrought iron.

The bridge, a deck structure, is about 2,770 ft. long, and runs southeast and northwest; owing to the course of the river at that point, the southeast end is on the right-hand or west bank of the river. The photographs reproduced in our Figs. 1 to 4 were taken at this end. The main portion of the bridge is of the viaduct type, with riveted spans of 80 ft. and plate-girder tower-spans of 40 ft. Four-leg towers alternate with two-leg bents. The southerly portion, south of this viaduct construction, comprises four 250-ft. pin-connected spans over the river, one 170-ft. pin-connected span on shore, and two 60-ft. plate-girders nearest the south abutment. The bridge has a sharp (4%) up-grade toward the south, so that the wrecked end was highest above the water. The two 60-ft. plate-girders were supported on two-leg bents on the slope of the bluff. Between the 170-ft. shore span and the first 250-ft. river span was a four-leg tower, 50 ft. long by 55 ft. wide and 129 ft. high from top of piers to bottom chord of trusses; as these trusses were 30 ft. deep, the roadway at this point was over 100 ft. above the water. Then followed a 250-ft. span, supported at its outer end by a two-leg bent, then another 250-ft. span resting on a four-leg tower at its outer end, then two more 250-ft. spans in similar arrangement to the two preceding. As the views indicate, the wrecked portion comprises the two end plate-girder spans, the 170-ft. span, and the two 250-ft. spans nearest the south end. These five spans, and the three two-leg bents and one four-leg tower included in them, were simply overthrown by the wind," falling eastward (the tornado approached St. Paul from the southwest, parallel to the course of the river at this point).

The bridge is 22 ft. wide between trusses. It carries a 25-ft. roadway paved with cedar blocks, and two 8-ft. sidewalks. The trusses were designed for a live load of 80 lbs. per sq. ft. of roadway and sidewalks for the 250-ft. spans, 90 lbs. for the 170-ft. span, and 100 lbs. for all spans shorter

FIGS. 3 AND 4. VIEWS LOOKING RESPECTIVELY NORTHEAST AND SOUTHWEST, FROM SOUTH END OF SMITH AVE. BRIDGE.

In left-hand view, Fig. 3, is seen part of the shore tower, 50 ft. long by 55 ft. wide, and 124 ft. high from top of pier to bottom chord of trusses. This view also shows where the 250-ft. span cut through a railway trestle as the tower fell over. Each of the four tower legs was held down by two 2¼-in. anchor bolts.

The right-hand view, Fig. 4, also shows parts of this tower, parts of the 170-ft. shore span, and the two 60-ft. plate girder end spans which were pulled forward by the falling of the two truss spans.

FIG. 5. HIGHWAY BRIDGE OVER MISSISSIPPI RIVER AT TENTH AVE., MINNEAPOLIS, MINN.

View looking north. Six deck spans of 200 ft. and 166 ft. Floor about 67 ft. above water surface. Part of floor stripped by tornado of Aug. 20, 1904.

than this. The lateral bracing was designed for a pressure of 450 lbs. per lin. ft. of bridge, of which two-thirds was assumed to act at the loaded (upper) chord. The towers and bents were assumed to have a wind-pressure of 150 lbs. per lineal foot of height acting against them.

The four-leg tower had one of its transverse bents fixed at the bottom, while the other bent was supported on rollers. The two-leg bents were arranged on rocking-plates for longitudinal expansion. In addition, one of the two legs had rollers for transverse expansion. Each leg, of all bents, was held down by two 2½-in. anchor bolts. The trusses meeting at a four-leg tower were in all cases fixed to the tower, while at the two-leg bents one truss had a fixed connection, the other a roller connection.

The lateral bracing of the long pin-connected spans of this bridge was, of course, composed wholly of rods, with cotter-pin connections at the ends. Many of the connection-plates, to which these rods were pinned, were of the bent-plate style now so generally distrusted. The design of the bridge, as a whole, seems to be much lacking in lateral stiffness, especially because of the abundant provision for expansion; such a condition possibly favors the attack of destructive winds of the kind active at St. Paul.

The Tenth Avenue bridge in Minneapolis, Fig. 5, is a deck truss bridge, about 1,100 ft. long. It has three spans of about 200 ft., and three of about 166 ft. The trusses rest directly on masonry piers, resting "on a foundation of limestone debris, which rests on the St. Peter sandstone." Mr. F. B. Maltby, who described this bridge in a paper* on "The Mississippi River Bridges," read before the Western Society of Engineers in 1903, says of the piers:

The piers are of limestone and have no cutwater or ice-breaker on the upstream end and the outer stones have disintegrated to a considerable extent.

The following particulars are taken from the same source:

Height of roadway above water, about 67 ft. Spacing of trusses, about 18 ft. c. to c. Trusses are of single-intersection type, with vertical end posts. Posts have castings at top and bottom through which the pins for chord and lateral connections pass. The pins at the foot of the end posts pass through a slotted hole in the bed casting to provide for expansion. It is evident that this pin does not move in the slot and that it serves as a rocker bearing for the end posts. In consequence the rods in the end panels of the bottom chord, which are mere idlers, have been buckled by being thrown into compression. The floor beams are a pair of trussed I-beams, and one of each pair extends beyond the chord and forms a support for the sidewalks. The roadway is of plank, 17 ft. wide, with two sidewalks of 5½ ft. each.

This bridge was built in 1872 by the King Bridge Co. It is evidently of wrought iron. As its construction is no more rigid than that of the Smith Avenue bridge, above described, it seems fair to assume that the wind pressure was lower than that against the St. Paul structure; this agrees with the newspaper reports that 110 miles an hour was measured in Minneapolis, while the St. Paul anemometer was blown over after recording a velocity of 180 miles an hour.

The two elevators shown in Figs. 6 and 7 stood side by side in Southeastern Minneapolis. They were the property of the Northwestern Elevator Co. The large elevator had the cupola torn off, and a moment later the smaller elevator was torn completely off its foundations and overturned (Fig. 7). This elevator appears to have been nearly empty at the time of the accident. The fall broke the timber cribbing that composes the bin walls along horizontal planes, as can be seen in the illustration.

We have to express our indebtedness for several of the views which we reproduce to Mr. J. H. Ritchie, of the Minneapolis "Journal."

*Journal W. S. E., August, 1903.

FIG. 6. GRAIN ELEVATOR NEAR ST. PAUL, MINN.; CUPOLA BLOWN OFF.

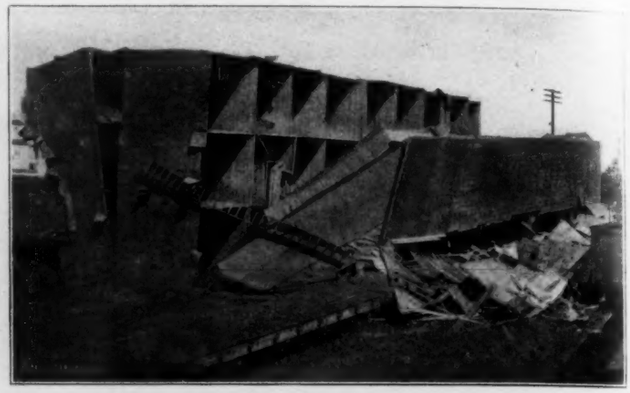


FIG. 7. CRIBBED WOODEN GRAIN ELEVATOR NEAR ST. PAUL, MINN.
Entire structure blown over. Roof over bins at right

THE ANALYZING AND GRADING OF IRON ORES.

By Edward A. Separk.†

In the discussion of this subject, we will confine ourselves to that portion of the Gogebic range operated by the Oliver Iron Mining Co. The ores mined by this company are a soft, red hematite containing hydrated and some blue steel hematite. On the whole, the blue steel hematite is slightly magnetic. The manganese occurs as dioxide and sesquioxide, pyrolusite and manganite being found.

Our sampling may be classified as: underground; hoist (embracing shipped and stocked); stockpile; and check and special samples. Underground samples are taken when the ore runs off grade at any shaft, this being done to locate some particular place that is causing trouble. When this place is found, the fault is remedied.

To make an estimate of ores to be shipped for the ensuing season, averages of the different levels, especially new developments, must be ascertained. The captains watch their respective properties, principally from an underground standpoint. They are kept in daily communication with the chemist, that he may be able to grade the stockpiles and hoist shipments judiciously. Samples are taken at the shafts underground from time to time, to check the landers' samples.

Managers have experienced different results from samples taken underground and from those taken on the surface, from the same ore. One reason for this, is that miners, careless in sampling, take the "pure quill" from places which may be intersected by portions of dike, and fail to foresee that after blasting, ore and dike will be mixed in such a manner that all the dike cannot be picked from the ore. As a result, we have a high percentage of iron and a low percentage of phosphorus in the underground sample, while the surface sample may show low iron and high phosphorus.

Samples taken from the top of cars underground holding one ton have differed from those taken from skips holding two tons of the same ore. The first carload in the skip might be high in phosphorus, while the second

*Abstract of a paper prepared for the annual meeting of the Lake Superior Mining Institute, Aug. 16 to 18, 1904.
†Oliver Iron Mining Co., Ironwood, Mich.

FIG. 8. TREES AND HOUSES ALONG BURR ST., ST. PAUL, MINN., WRECKED BY TORNADO OF AUG. 20, 1904.
Shows how portions of roofs were torn off, and how shingles were ripped off in patches. The latter effect was observed in many cases in and around the Twin Cities.

car might contain ore low in phosphorus, the two cars coming from entirely different places.

In taking a sample from the breast of a place, a good method to follow is to pick the sample from cross sections of that place—that is to say, at regular intervals in a horizontal and perpendicular lines. Broken ore leaving a room or place for any set period of time may be very well sampled by taking a trowelful from each car and making a sample from the average trowelfuls of ore. When sampling the entire mine it is very essential to note the number of cars leaving the rooms. Quantity is an important factor.

Hoist samples are taken from the various shafts. The lander is directed to take a small trowelful of ore from a particular place in each skipload that is hoisted, and to place it in a large, shallow box. Separate boxes are provided for each grade, bell signals designating the different grades hoisted. The ore in the boxes is taken by a laboratory sampler every 12 hours from the shafts having a heavy production, and from those of light production, every 24 hours.

At the shaft, the sampler breaks, mixes, and quarters the ore on an iron plate until the sample is of a size to fill an 8 x 14-in. canvas bag. Each sample taken, contains a printed slip bearing a full description. These slips are wrapped in paper to prevent coloring and moistening. Minor details should not be neglected.

Stockpile samples are taken from the railway cars and treated the same as hoist samples. Two samples are taken from the day's shipments and are designated as "A. M." and "P. M." Stockpiles running very irregularly demand a sample from every 10 or 15 cars, this latter being done chiefly at the Tilden mine. Their stockpiles are sampled by taking a trowelful from each dipper of the steam shovel. In stocking the ore a weekly sample is taken from the stockpile by the laboratory sampler in order to reasonably check the lander's samples.

Samples are taken from the faces of the stockpiles each spring. Best results have been derived from samples taken at the "rill" of the stockpile (just where the fine ore is in contact with the lump ore). In taking any sample it is far better to take from the fine ore entirely, than to have too much lump ore in the sample. It is easily understood that there would be a better average in fine ore than in lumps. Experiments have proved this to be a fact. When lump ore and rock are encountered in sampling, small portions should be broken off from these lumps and rocks, (judgment must be used in averaging the pile). As far as possible, ore mined should be free from rock and large lumps of ore. It is ore the chemist wishes to analyze, not rock. The specific gravities of rock and ore differ so widely, it is difficult to obtain a proper average of a rocky sample. Samples are taken, by the chemist, from the stockpiles, from time to time, to check the laboratory samples, and the mine chemist's samples are often checked by the chemist of the fee owners. Specimens of ore, dike, rock, etc., are collected and analyzed, as they are of interest.

All samples are brought into the crusher house, emptied into pans, dried at 212° F. by a steam heater, after which it is passed through a "Gates" crusher, so it will pass a ⅝-in. mesh. A smaller crusher takes this and reduces it to a coarse powder. Every precaution is taken to keep the crushers clean.

The crushed sample is quartered; one quarter of which is kept as a reserve sample, while the other portion is quartered to a small handful. This is reheated in a small pan at 212° F. (Pans without tin are best because foreign matter from pans might get into the samples and cause considerable annoyance.) Care should be taken to prevent overheating the sample as it causes an escape of the water of crystallization and burns out the organic and volatile portion. All constituents of the ore would be obviously changed.

After the sample is dry, it is "bucked" on a chrome steel plate by a chrome steel muller. Cast iron plates are brittle and give up iron filings to the sample. Chrome steel plates are very much better, because the steel is tough and does not give up filings to any appreciable extent. The steel plates must be cleaned and brushes dusted after each operation.

This sample is passed through a hundred mesh sieve; the portion that does not pass through at first is "re-bucked" and made to pass through. The pulp is well mixed and placed in an envelope for analysis at once.

The samples bear a number identical with the sample description. The chemist receives the sample descriptions each day. By such a system of numbering the analysts do not know the description of the sample, and consequently cannot presuppose their results.

The ores of the Tilden mine are analyzed at their own laboratory at Bessemer. The Norrie laboratory at Ironwood does the work for the others, and does all grading of the ore. Both laboratories use the same methods.

Complete analyses are made each month on the pulp sample made from ores produced that month, and a com-

FIG. 9. FRAME HOUSE ON 8TH ST., ST. PAUL, MINN.
Front Wall Torn Off.

FIG. 10. FRAME HOUSE PUSHED OFF ITS FOUNDATION.
Note that the side dormer roofs were torn off, the ridge-capping torn off the whole roof, and part of eaves broken away.

FIG. 11. RUINS OF TIVOLI THEATER (FRAME STRUCTURE ON RIVER BLUFF), ST. PAUL, MINN.
A performance was going on in the theater when the tornado struck the city. Several persons were killed in the collapse of the building.

FIG. 12. THREE-STORY FLAT-ROOF FACTORY BUILDING AT ST. PAUL, PARTIALLY WRECKED.

plete analysis is made at the end of each shipping season on the average pulps of all grades shipped for a season. The basis in weighing these complete pulp samples is, one gram of ore equals one thousand tons.

Samples are very often given to the analysts to check their own work.

In order to feel the market, pulp samples of the ore are sent to the various iron ore and steel chemists to ascertain how their standard ores are analyzing. At this point there is sometimes a great deal of satisfaction found but at other times there are many discrepancies.

In sending out standards for analysis, the powders should be absolutely mixed. A guarantee of the ores is placed by the company before navigation opens, and in sending out this ore we must keep our shipments running within the limit of iron, phosphorus, silica, manganese, etc. To do this our stockpiles have to be of more or less uniformity, also the ore shipped from the shafts. Sometimes one pile of ore may be a little over the guarantee, for example, high in phosphorus, but may be remedied by mixing it with a corresponding low phosphorus pile. Every precaution must be taken with piles without plank bottoms lest the steam shovel may disturb the surface of the earth. When an ore runs off grade in any particular property, it is gradually worked off at the docks. When a grade runs outside the limit (the Tilden mine especially) the cars are held until they can be worked off. At all times when the ore runs off grade, investigations are made.

All records of the analyses are kept in systematic order.

The results are transferred from the analysts' note books to a "Daily Record of Analyses" ledger. Daily reports are telephoned to the different mine captains. A copy of all results is sent to the Duluth office and one is held at the superintendent's office. The ore clerk furnishes the laboratory with a daily tonnage report. During stocking season the ore is estimated, a leaning to the over-run being made, and in shipping season the tons are adjusted as near the railroad weight as possible.

A ledger showing the shaft and stockpile results and units (multiplications of tons by percentages), of ore shipped and stocked is posted daily. This book enables any average of grades, at any shaft or stockpile to be ascertained readily.

The results of shafts and stockpiles are averaged monthly, previous months added and an average shown for the season. All multiplications and calculations are kept in books for future reference and to save time in figuring. Averages are kept in a special book for the different properties. The property results are figured daily, and for season ending each week. Each month a copy of the averages of shafts and stock piles and averages of entire grades are compiled for month and season.

The mine shipping clerks send into the office a daily report showing the number of cars and grade of ore of all shipments to the Ashland docks. The shipping clerks date these bills when the cars are loaded.

A separate set of waybills for each grade of ore at each mine is received daily from the Ashland docks, giving car numbers and weight of ore in each car. A card accompanies these waybills showing ore on hand per last report, ore received as per inclosed waybills, and shipments with name, date and tonnage of vessels leaving, and finally balance on hand to be carried forward on the next day's report. All waybills are compared with the mine shipping clerk's report and the car numbers checked off. In doing this work the ore clerk places opposite each car number the date which he finds on the shipping clerk's bill on which that car occurs. From the date as obtained above, it is possible to compute an approximate analysis for the total number of tons of the waybills for each property grade of ore, which total number of tons appears on the cards accompanying the same. These tons averaged with balances on hand at docks will give an average analysis for all of the different property ores in docks. The ores in the cargoes clearing at that time, are given the same analyses. This system of handling the cargo has been checked several times by obtaining a car list of cargoes. The difference between this procedure and the regular system explained above, checked within 0.10% in iron and 0.001% in phosphorus.

In our method it is essential to see that cars are hurried to the docks and emptied, and that the ores already in the docks do not stand there too long. Cargoes take ore as grades, thus all of the different property ores comprising any one grade are averaged in order to obtain one analysis for the cargo. The analyses of the total number of tons of waybills are obtained as follows: The assumption is made that all small cars carry the same weight of ore, and all large cars carry the same weight of ore. A large car (over 60,000 lbs.) is considered as being equal to two small cars, the small cars being considered the unit. The number of cars having the same date of sample is noted and given the daily average analysis of that property for the corresponding date. The number of cars for each date appearing on the waybills is treated in a similar manner and from these like averages of the total number of tons of the waybills is computed.

It may be well to state in this connection that these total waybill weights appear on the monthly royalty reports and the analyses as above figured are used on them also.

A daily report of cargo analyses is made, showing the vessel weight (1% less than railway weight), units of iron, phosphorus, silica, manganese and moisture. The tonnage of the cargo is reported to the nearest ton. Daily determinations of moisture are made from the different shafts and stockpiles and the average for this substance is made from these determinations. The cargo units are booked per grade and the total units are added monthly, and sent to Duluth to be checked with their records. Previous months are added, and average percentages of the different grades are ascertained for the season. These results are checked by the season pulp samples as already explained under analyzing. The cargo results should check with the season monthly mine reports, computed from the daily monthly reports.

Production of each grade is averaged for the season and if all produced has been shipped, the production should agree with the season cargo report and monthly season report. As an illustration, for the season of 1903, the Norrie grade shipped 757,686 tons (vessel weight) by cargo, analyzing 63.11 iron,—.03748 phosphorus, the season pulp sample 63.20 iron,—.038 phosphorus. This pulp sample was sent to four outside chemists. Their average analysis was 63.09 iron,—.039 phosphorus. The average of all ores of the Norrie grade shipped to Ashland docks for season 1903, per mine report, showed 63.11 iron, —.0374 phosphorus. The different works of the Carnegie Steel Company's average analysis of the ore, for that season up to Sept. 1, was 62.97 iron, —.038., phosphorus.

Sharp lines in grading cannot be obtained if the ores are mixed accidentally at the docks, ports, and furnaces. It must be handled as carefully at the furnaces as at the mines. If this is not done, all of the chemical labors prove of no avail.

The cost for crusher house work, laboratory and sampling results in the year 1902 for the Norrie and Tilden laboratories amounted to $9,550. There were 40,7[illegible] determinations made; thus the average cost per determination for supplies was $.0574; the labor cost per determination was $.1766; the total cost per determination $.2341. The cost on actual pulp sample (excluding [illegible] and figuring) amounted to $.0551 supply cost; $.11[illegible]

FIG. 13. CHURCH BUILDING, 19TH AND PORTLAND STS., MINNEAPOLIS, MINN.

Fig. 14. Tin Roof Covering Caught on Telephone Wires, Minneapolis, Minn.

RECORD BREAKING ORE HANDLING at Lake Superior mines and docks in the week ending Aug. 20 is reported as follows by a correspondent of "The Iron Age":

In one day this week the docks of the Duluth & Iron Range road transferred to ships 87,835 gross tons of ore, breaking all records. This ore was put into 16 vessels, showing an average cargo of 5,490 gross tons. In this connection a figure or two will be interesting. In 1890 the "Matos," of the then Minnesota Iron Co., was the largest carrier on the lakes, with a capacity for 3,000 tons, and the average cargo of larger ore ships for three to five years after was about 2,500 tons. To-day the average of the ore vessels is better than 5,000 tons, and it is quite evident, from the size of ships now undertaken, that this will be hoisted in another year or two to 8,000 to 8,500 tons. The "Wolvin" is a 10,000-ton ship, the "Sahara" carries 8,500 tons, and the "Sahara's" owners have just let a contract for a vessel that will carry at least 9,000 gross tons. By the way, in 1890, there was scarcely a ship owned or registered at Duluth; now the city has a larger registration than any other port on the lakes, and the three biggest ships, just mentioned, are all built and operated by Duluth syndicates.

Loading records had another jolt this week in the performance of the new docks of the Chicago, Milwaukee & St. Paul road at Wells, Mich., a day or two ago, when the "F. H. Peavey" took 6,585 gross tons of ore in 51 minutes. No especial preparation had been made for speed, and a delay of 15 minutes occurred in running down additional ore from cars. The same road has been hauling to dock trains of 4,200 gross tons of revenue load, still another record.

Burt mine of the Oliver Iron Mining Co., on the Mesaba range, is shipping with the utmost vigor, heavier than any property in the lake region. On Wednesday of this week 450 carloads, or 18,000 gross tons, were loaded and shipped to Duluth docks. Three steam shovels and 150 men were employed in the work, with a payroll aggregating less than $400. To be sure this is an unfair method of computation, for the cost of stripping this ore body should be included in any estimate cost. Still, stripping and loading combined can hardly be more than 10 cents a ton. This is a new mine of the U. S. Steel Corporation, opened only last year, and is arranged for exceedingly low costs. Its August shipment should be nearly 400,000 tons. A portion of this mine is owned by the State of Minnesota.

Rates have dropped 5 cts. a ton from the head of the lake, and are now 65 cts. from Duluth, Two Harbors and Ashland. This is about low point for iron ore for many years.

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ADVERTISING RATES will be furnished upon application. "Want" and "For Sale" notices (special rates), see pages 26-27. The pages for new "Want" "Proposal" and "For Sale" advertisements are held open until Wednesday noon.

The value of exports of manufactured articles just now exceeds the value of agricultural products exported, for the first time in the history of the United States. This is, of course, a temporary condition, existing during the summer months, while exports of wheat, cotton and corn are at a very low ebb. For the fiscal year ending June 30 last the total value of exports of domestic manufactures was 450 million dollars in round numbers, and the value of agricultural products sent abroad in the same time was 850 millions. It is true, however, that agricultural products form a smaller percentage of the total value of our exports year by year, due not to any falling off in the quantity of our farm products sent abroad, but to the enormous growth in our exports of manufactures. For 1890 our domestic manufactures exported amounted to only 151 million dollars. For 1904 (the fiscal year ending June 30) they amounted to over 452 million dollars.

The Chicago drainage channel has been a profitable investment, even if entitled to no more than half of what is claimed for it by Dr. Arthur R. Reynolds, Chicago's Commissioner of Health, in his bulletin for the week ending Aug. 20, 1904. The channel was opened in January, 1899. The deaths and death rates from intestinal diseases for the four years before and the four years after the channel was opened are reported and commented upon by Dr. Reynolds as follows:

Deaths from—	Four years. 1896-1899.	Four years. 1900-1903.
Acute intestinal diseases.....	8,119	8,898
Rate per 1,000 of population..	16.41	12.44
Typhoid fever	2,266	2,235
Rate per 1,000 of population..	3.68	3.10

If the rate of the four years 1896-1899, before the opening of the drainage channel, had obtained during the last four years, there would have been 11,724 deaths from the acute intestinal diseases and 2,629 from typhoid fever, or 2,826 more from the former and 394 more from the latter (a total of 3,220) than did actually occur.

The money value of these 3,220 lives—$16,100,000—is only one item to be placed to the life-saving credit of the drainage channel; a larger, but intangible amount, would accrue if physical suffering of the victims, mental suffering of parents, wives and husbands, and impairment of vital resistance of the survivors could be figured out in dollars and cents.

From the standpoint of public health the drainage channel is the best investment Chicago ever made.

We think it certain that some of the credit for this remarkable showing is due to other improved sanitary conditions, but doubtless most of it is rightly credited to the improved water supply, due to the diversion of the sewage from the lake. Direct evidence of this improvement has been shown by the analyses of the water supplied to the city. On this point the latest evidence, as presented by Dr. Reynolds, is as follows:

For the second time in ten years a rainfall of more than 0.75-in. in 25 hours has failed to cause contamination of the public water supply. The first on record was that following the rainfall of July 31 ult., which was more than 0.9-in. During the 24 hours ended at 7 p. m., Aug. 19, there was a precipitation of 1.27 ins., but the chemical determinations of Aug. 20 showed a purer water at each of the nine pumping stations than samples taken seven miles from shore and identical with samples taken twelve miles from shore.

Such results should stimulate other cities to make much-needed improvements in their public water supplies. Pittsburg, of all the large cities in the country, is probably in the saddest plight as regards its water supply. Notwithstanding its enormous yearly losses of population through the ravages of typhoid fever the people supinely permit their political bosses to dilly-dally with the water filtration improvement authorized by popular vote years ago.

In view of the varied experience of British cities with sewage disposal schemes, no little interest is attached to the comments of the London "Surveyor" on the ground recently taken by an official of New York City in opposition to the proposed outlet of the Passaic Valley trunk sewer into New York Bay. In its issue of Aug. 12, the "Surveyor" says:

An interesting light is thrown either upon the density of American "political" nominees or upon the lengths to which the craze for office will lead them, by a recent utterance of the President of the New York Board of Health. The municipal authorities in the Passaic Valley, in the northeastern part of New Jersey, have decided to lay a trunk sewer, about 24 miles in length, discharging into the main channel of New York Bay, where the water is very deep. Against this the official referred to sees fit to protest, and if he had confined his objections within reasonable limits no great harm would have been done. But he takes the ground that there is no need to expend so many millions on a scheme of this character. He asserts that the local authorities "ought to spend the money in erecting plants for the conversion of the sewage into an asset" in order to obtain "profit from the sewage by extracting acids, fertilizers and other products from it, *as many cities are now doing.*" We italicize that portion of this diatribe which we believe will possess most interest for English sanitary engineers, whose energies are taxed, in hundreds of places, to dispose of sewage without nuisance, not only without an attendant profit, but accompanied by inevitable loss. They will, we are sure, wish to know the names of those cities in which this dream of a past generation of hygienists is being realized, and, we have equally little doubt, will be disposed to submit the data to a very close scrutiny before accepting them as corroborative of the President's assertion. The belief in the practicability of extracting sovereigns from sewage was once as firmly entertained as the chimera of squeezing sunbeams out of cucumbers, the only justification in either case being that the one process was as likely to succeed as the other. We have a great and abiding respect for American ingenuity, but this is clearly a case of vaulting ambition o'erleaping itself and falling—literally—on "the other side."

As to the opening sentence of the foregoing quotation, we have no comment to make. The remainder of the quotation we commend to those American newspaper editors and health officers whose zeal in promoting municipal sanitation and economy far exceeds their knowledge of the real character of the sewage disposal problem.

The occurrence of another robbery of a contractor's paymaster serves to call renewed attention to the wisdom of thoroughly guarding paymasters who have large sums of money to deliver at contract works. Only a few months ago a contractor's paymaster was killed in Pennsylvania by the explosion of dynamite, which had been placed under a small bridge over which the paymaster's buggy was passing. The murderers and robbers made their escape with the bag of money. Now comes the account of a bold holdup near Montclair, N. J., on Aug. 23. Four men, after shooting the paymaster's horse, got away with about $5,000, which was being taken to the laborers on the Cedar Grove Reservoir. It appears that two guards accompanied the paymaster in the same buggy, but they were armed only with pistols, which they did not have an opportunity to use.

It is well worth consideration whether some system of checks might not be devised for the payment of laborers on contract works. Suitable precautions would have to be taken, of course, by punching or otherwise to prevent the raising of the checks, and special arrangements would have to be made for their payment on presentation at some nearby bank. Such a plan would really be in the interest of the workmen, for their weekly wages are more likely to be spent or lost if paid in cash than in a certificate good for the money on presentation.

It would be easy, too, for the bank paying the checks to arrange to transmit money elsewhere to holders of checks desiring it, and to accept deposits on account of some nearby savings bank.

Of course much contract work is carried on at a long distance from any town containing a bank of deposit, and here cash payments may be unavoidable. There are many other cases, however, where by taking a little trouble a system of check payments could be easily established and the risk and expense of carrying large amounts of cash to contract camps could be avoided.

The courtesy of an explanation is due to a valued correspondent, who chides us mildly for having made no mention of so important an event as the passage of the first train through the Simplon Tunnel, which, as he correctly states, was announced in the newspapers some two weeks ago. The reason that we have hesitated to grant space to this report, even with the example of an esteemed engineering contemporary before us, is that its truth seemed highly improbable. On Aug. 1, according to the official reports, there remained 425 meters of heading to be driven before the advance workings from the two sides of the mountain would meet. During July and, in fact, ever since May 18, work has progressed from the Italian end alone owing to the breaking out of hot springs in the advance heading from the Swiss side. The progress during July, from the Italian end, was 209 meters. By doubling this progress the heading could hardly be completed by Sept. 1, but to complete it by Aug. 15 would require that the speed be quadrupled. This is rather greater progress than can be expected, and has led us to believe that the newspaper celebrations of the "first train through the Simplon" were a trifle premature. It may be noted further that even if the headings had met, as was stated, the first train through could have been only a narrow gage construction train, since the length of full section to be excavated is some 2,000 meters greater than the length of heading, and this must be completed and lined before regular trains can pass.

The comparative volume of dredged material when measured in place and when measured in the scow after excavation, is a subject which was brought forward in some correspondence on the work done by the dredges on the St. Lawrence River, published in our issue of Aug. 11. In the St. Lawrence River dredging, it is stated that the place measurement is taken as 80 per cent. of the scow measurement. On the Stony Point section of the Buffalo Breakwater, 10 ft. apart, the cross-sections were carefully taken before and after dredging, and a comparison of this measurement with the measurement of the material taken away in scows showed an increase of 7.6 per cent., according to a report on the work by Mr. Emile Low. The material was red clay.

On the South Harbor section of the Buffalo breakwater similar careful cross-sectioning was done, and we have just received the following report of the comparison of place and scow measurement in this work from Lieut. P. S. Bond, the Engineer now in charge:

The trench excavated for the foundation of the South Harbor section of the Buffalo breakwater resulted in the removal by dredging of 357,461 cu. yds., scow measure, of soft clay. The place measure of the material dredged, as determined by cross-sections 10 ft. apart of the completed trench, was 323,356 cu. yds., showing an increase or "swelling" of 10.4%.

The disaster of Aug. 7, near Pueblo, Colo., on the Denver & Rio Grande R. R., in which 96 persons lost their lives through the fall of a crowded passenger train into a swollen creek, deserves wider

attention from engineers and railway officers than it has received.

The Ashtabula bridge disaster of 1876 aroused horror throughout the civilized world, and had an important influence in changing the practice of American engineers with reference to bridge construction. But the number of lives lost at Ashtabula was actually less than in this recent disaster on the Denver & Rio Grande. Is such a calamity as this to be accepted as a visitation of Providence,—something impossible to foresee or provide against, or does it contain lessons which those in charge of railway permanent way ought to heed?

Elsewhere in this issue we print the verdict of the coroner's jury upon the accident; and the circumstances in connection with it are made fairly clear. The disaster occurred at a ravine a little less than 100 ft. in width, which was spanned by a wooden trestle. The channel appears to have carried little or no water at ordinary times, but to have been filled nearly bank full at the time of the disaster by a very heavy local shower.

The trestle appears to have been a substantial structure, as trestles go, barring its apparent lack of longitudinal bracing, in which it was doubtless no worse than many other trestles now in service on highly respectable railways, but no trestle engulfed in a torrent is a safe structure to run trains across. The coroner's jury says in effect that some better structure than a trestle ought to have spanned that opening; and with damages for the loss of nearly a hundred lives confronting them, the railway managers are doubtless of the same opinion now.

We are well aware that the task of replacing trestles with earth fills, and masonry or metal bridges is one that cannot be done at once but must of necessity be distributed over a period of years; during which time the wooden trestles must continue in use; but during that time the public which uses the railways has a right to demand that safety be made the paramount consideration. In times of flood or heavy rainstorms, such as occur every season on a large proportion of our railway mileage, a company with a permanent way of the highest class and with its water-way openings built in the most substantial manner, can continue to run its trains on schedule speeds. For a company with second rate or third rate tracks to do this, however, simply means taking chances with fate. Such a company should expect to incur considerable extra expense for watching the known weak points on its line during heavy rains in summer or thaws in winter, and should run trains with exceptional caution at such places during such seasons.

One main cause of the prevalence of accidents on American railways is that we are running trains on many roads at higher speeds than are justified by the character of the permanent way or the system of train operation in use.

It is fair to add, in justice to the engine runner who perished with the rest in the flood, that he appears to have run his train very slowly at the fatal trestle, appreciating doubtless the fact that after the great rainfall, evidences of which must have been all about him, that the trestle ahead might be unsafe. So slowly was the train moving, in fact, that while the engine and the first two cars went down, three Pullman cars behind them remained on the track. Had the engine runner brought his train to a full stop and investigated the condition of affairs before proceeding, the lives of nearly a hundred people might have been saved. He very likely reasoned, however, that if no trackman was there to warn him, the bridge must be all right, and it was his duty to go ahead.

When the execution of any important engineering work is determined upon, one of the first and most difficult problems to be considered by the engineer is that of planning how the work is to be done. Thus in the construction of a bridge, the design and building of the bridge itself may be a comparatively simple matter, but the shipment and handling of the material and the methods of erection, may involve many difficulties. If the bridge is to be erected in a wild mountainous country or on a busy trunk line crowded with traffic, the difficulties are greatly increased. The erection of viaduct No. 2 on the Guayaquil & Quito Ry., described in our issue of Aug 11, is a case in point. Another instance is afforded by a short piece of track elevation work now in progress in Chicago. This consists simply in building retaining walls, putting plate girder bridges over the streets, and filling in with sand or earth. But the piece of line includes two double-track main lines approaching city terminals, and constantly in use for regular and light trains, engines and switching movements. A passenger car yard, a small local freight yard, and spurs to industrial works are involved, while the work is complicated by the switch and signal equipment, interlocking plants, grade crossings, etc. Accommodation for the passenger and freight cars has had to be provided further out, which in turn increases the traffic, as all light or empty passenger trains have now to be run to and from one of the terminals over the track elevation work. Then the main tracks had to be shifted from time to time to allow of building the retaining walls at the side of the right of way. Piles also had to be driven in and between the tracks, and stringers put in to carry the rails over transverse excavations for the foundations of abutment walls at each street crossing. Every change of track of course necessitates changes in frog and switch work, in signals, and in all the mechanical and electrical connections. In addition to this plans have to be studied out for delivering and handling the construction materials, mixing and depositing concrete, handling and placing stone blocks and bridge girders, hauling away the excavated dirt and later on bringing in the filling. All this must be done so as to give the greatest economy, facility and safety for carrying on the work without interfering with or endangering the safety of the regular traffic. The engineers in charge of work of this kind must possess not only professional skill, but also executive ability, readiness to meet emergencies, and a familiarity with operating conditions. To the younger and subordinate engineer, work of this kind is an excellent experience at the outset of his professional career.

SHOULD A PERCENTAGE OF MONTHLY ESTIMATES BE RETAINED UNTIL FINAL ACCEPTANCE?

In our issue of Aug. 18 we commented upon the lack of uniformity in requirements as to the amount of security accompanying bids. A matter of even greater importance to contractors is the percentage of each monthly estimate retained until final acceptance of the work. From 10 to 15 per cent. is commonly retained, but it is not unusual to see a specification in which it is stated that 25 per cent. will be held until completion, and occasionally a contractor is temporarily deprived of a larger percentage of money which is really his own. The larger the contract and the longer its life, the more serious becomes the burden put upon a contractor by depriving him of part of his working capital. Why is any money retained at all after the materials have been furnished and the work done? The natural reply is: "Simply to make assurance doubly sure." The contractor is usually under bonds to complete the work, but there is additional security in holding up as large an amount of the contractor's cash as possible. Is this right? Is it good business practice? It may be urged that so long as contractors are to be found who will submit bids under such conditions, it would be foolish not to get all the security possible. But, on the other hand, if we consider a contractor's capital as he himself considers it, we may change our minds. With abundance of money to be had at legal rates of interest for the asking, no contractor would be burdened by having all his earnings tied up; but unfortunately for him, his borrowing capacity is limited. He must pay cash to the laborers, and if he gets more than 30 to 60 days' time on the materials, he usually has to pay an excessive price in consequence. "Ten per cent. off for cash" is an expression that few engineers think of, but it means much to contractors. It should mean much to the engineer also, for he seeks to make the cost of the work as low as possible. He may rest assured, however, that in the long run his clients will have to foot all the contractor's bills. Of course, there are large contracting firms who can bid on a cash basis most of the time, but they are scarcely representative of contractors in general.

Still it may be urged that the additional security of having a large percentage of cash held back, is worth all it costs. Is it? What are bonds for, if not to furnish security? And if they are not good security they simply serve to add to the contractor's burden, and so increase the cost of the work. Bonds given by business men or owners of real estate are usually paid for in one way or another. Bonds given by surety companies are always paid for, but at a definite and comparatively low rate. The bonds of such companies are as good as the cash percentage retained in every respect save one: The surety company may contest its responsibility after a contractor's failure to perform. Such a contest is usually based upon an alleged change in the plans without the surety company's knowledge, for in nearly all cases of successful contest that has proved their only loop hole of escape. But the engineer having a full knowledge of this fact, would be weak indeed if he were still influenced by the vague fear that the bondsmen might escape and so leave no security unless a cash percentage were retained.

We are inclined to think that retaining a cash percentage had its origin in fear: First, that the bondsmen might prove to be "dummy bondsmen," that is, irresponsible; and, second, that overestimates might be made in the monthly measurements which the contractor might take advantage of by abandoning the work. This last consideration may be dismissed as unworthy of serious comment; and the first consideration deserves only a word. "Dummy bondsmen" are, and will continue to be, a source of occasional loss; but a little vigilance will reduce the chance of loss to practically nothing, and the requirement of surety company bonds will reduce it to absolutely nothing.

It would appear from these and other reasons that there exists to-day no good and sufficient reason for holding back all of a contractor's profits until the completion of the work, for such in fact is the retention of 10 to 25 per cent. of the value of work done. Profits should be more often looked upon as salaries than as interest on capital. To the small contractor his profits really are his salary, and little else. Not to receive one's salary at least once a month is to say the least discouraging, and to have it held up for several years may in fact be ruinous. In our issue of Aug. 25 Mr. S. Whinery cites the Erie Canal contracts under the "nine-million job" as an example of held-up certified checks; it serves also an example of held-up salaries.

If any percentage at all is to be retained until completion of a contract, it should be a very small percentage, preferably not more than 5 per cent. or possibly 10 per cent.; and it is exceedingly doubtful whether any money at all should be held up, for if is certain that the state, or city, or company pays usurious rates of interest in the end on all such money. It may be in the form of higher prices, due to limited competition, or it may be in the form of higher prices for materials upon which the contractor is unable to get a discount for cash payment, but in some form or other the buyer foots the bill. Finally there is the element of "graft." On large contracts the 15 or 20 per cent. retained often becomes a political "plum," or more truly a plum-tree to be plucked by favored bankers. We shall welcome any discussion of the subject of this editorial, particularly in view of its economic importance.

LETTERS TO THE EDITOR.

Corrosion Produced by Rain Water in Steam Boilers.

Sir: Referring to your editorial on scale in steam boilers in your issue of July 21, I quote the following from my "Steam-boiler Economy," p. 313:

> The purest waters, such as rain or melted snow, . . . if used in boilers, the inner surfaces of which are clean and unprotected by a coating of scale, may cause pitting of the plates and more or less general corrosion. The corrosion produced by such water may usually be prevented by occasionally adding a little milk of lime to the water, just enough to form a very thin coating of scale."

Wm. Kent.

Syracuse University, Syracuse, N. Y., Aug 15, 1904.

Notes of Experience in Field Riveting Desired.

Sir: As a "Bucker" I would like to inquire of your readers what kind of a rivet hold-on or dolly is found satisfactory in riveting up the top chords and posts of small Pratt trusses for either hand or air work. Air. buckers are of course available on a pneumatic job but ram dollies or spring dollies are not practicable in the place suggested.

I would also like to be referred to a description of a portable air plant for riveting up railway bridges of 2,000 to 15,000 field rivets. Your truly,

F. T. Darrow.

Lincoln, Neb., Aug. 17, 1904.

Headquarters of the American Society of Mechanical Engineers at the St. Louis Exposition.

Sir: In your notice regarding engineers' headquarters at the World's Fair, page 182, issue of 25th inst., you do not mention the room of the American Society of Mechanical Engineers, situated at the south end of the East Gallery of the Palace of Machinery. These quarters are comfortably furnished, and are open throughout the day, with an attendant in charge. All current publications of interest to mechanical engineers are on file, together with the proceedings and literature of the society. Access is easy by means of an automatic electric elevator which lands the visitor immediately alongside the room.

Very truly yours, William H. Bryan.
Secy. Local Committee.

329 Lincoln Trust Bldg., St. Louis, Aug. 27, 1904.

(We take occasion to add that the Verein Deutscher Ingenieure also has headquarters established at the St. Louis Exposition, in the Machinery Building, Mr. F. Froelich being in charge. —Ed.)

High Steel Chimneys in America.

Sir: I notice in your issues of July 21 and 28 an inquiry and an answer in regard to high steel stacks in America. I would say that our company has built no less than a hundred steel stacks 200 ft. high and several much higher. Without referring to records I recall the stack for the Cleveland Electric Illuminating Co., 225 ft. high, 11 ft. 6 ins. internal diameter, 24 ft. diameter at base; the stack for the Compania de Penoles, Mapimi, Mexico, 300 ft. high, 14 ft. internal diameter, 24 ft. diameter at base. The stack of the greatest diameter that I know of, we erected last year for the Copper Queen Consolidated Mining Co., Douglas Arizona, 200 ft. high, 25 ft. internal diameter, 34 ft. diameter at base.

Yours very truly, Wm. C. Coffin,
Vice-President, Riter-Conley Mfg. Co.

Pittsburg, Pa., Aug. 11, 1904.

Oil Motor Cars for Railways.

Sir: In the article on "Motor Cars on European Railways" in Engineering News of July 28, we find that in the short paragraph referring to the car we have built to the order of the Great Northern Ry. you refer to a letter by the Locomotive Superintendent of this railway, saying that he did not know when the car would be ready.

The car without the seats was delivered to the Great Northern Ry. for preliminary test and trial three weeks ago and it has now made numerous successful runs. It is shortly to return to the shops at Doncaster for the fitting of the seats, when it will be brought into use.

We note that other cars which, we believe, use petrol, or petroleum spirit are described as oil cars, but so far as we know at present ours is the only car using ordinary petroleum or kerosene oil yet built in this country.

Yours faithfully,
The Roots Oil Motor & Motor Car, Ltd.

London, England, Aug. 15, 1904.

Zinc Sheets for Plane Table Work.

Sir: A short time ago I made a topographic survey covering 2,200 square miles by plane table methods. This survey covered the territory lying between the summits of Steins and of Warner Mountains, Oregon. The physical features and work of man were minutely represented to a scale of four inches to a mile.

The work was carried on without interruption from beginning to end.

Many of your readers who have been engaged in plane table work are doubtless aware of the annoyance experienced when paper plane table sheets get wet while working in the field.

It might be of interest to such to know that I entirely overcame this difficulty by employing sheets of thin zinc. The construction lines and the physical features were first pencilled upon the zinc. Then at odd spells, or when the day's work was done, with a sharp stylus, I would engrave the physical features upon the zinc.

When the sheet was completed, with a piece of waste I would apply over the sheet a mixture of lampblack and linseed oil. After wiping the surface bright with a dry piece of waste, the engraved lines would stand out sharp and black, and the sheet would present a very workmanlike appearance. Yours truly,

Ralph E. Parker.

P. Ranch, Burns, Ore., Aug. 6, 1904.

Engineering Exhibits at the St. Louis Exhibition.

Sir: No doubt there are many who read your "Review of the Engineering Exhibits at the St. Louis Exhibition" with considerable interest. I did so, because of the fact that I had visited the exhibition, and was anxious to know what objects of engineering interest I had failed to see. The list is most comprehensive, but there is lacking an answer to one question that would aid the visitor more than any one thing else, in studying the various displays. That question is, in what buildings the various exhibits are located? It is to be regretted that there is not available for public distribution a classified list of the exhibitors or the articles displayed. The exposition is in itself so large that it requires almost two whole days to visit the various buildings, in order to locate the exhibits that are interesting to the engineer.

As the review recites, the various branches of the engineering science are so thoroughly represented that there is hardly a field not covered. There are 13 exhibit palaces, 34 state buildings, 17 foreign pavilions and about a dozen special buildings that might command our attention, had we the time; but most of them receive little or no attention. If in the review of the exhibits some sort of a classification could be arranged, whereby the various displays of one branch of engineering could be grouped, it would doubtless be of great advantage to the prospective visitor. He would be able to select those subjects which he desired to investigate, and without touring the entire exposition locate the objects of his interest.

Yours truly, Frank E. Hahn.

Philadelphia, Pa., Aug. 13, 1904.

Determination of Impalpable Powder in Cement.

Sir: My attention has been called to an inquiry from Mr. A. W. Munsell in your issue of July 28 in regard to methods for determining the fineness of cement below a No. 200 sieve. In connection with a book on concrete which the writer is preparing in collaboration with Mr. Frederick W. Taylor, M. E., I have been making extensive researches in the literature on the subject of cement and concrete, and will cite a few references to data, relating to methods of separating particles of cement finer than those retained on a No. 200 sieve.

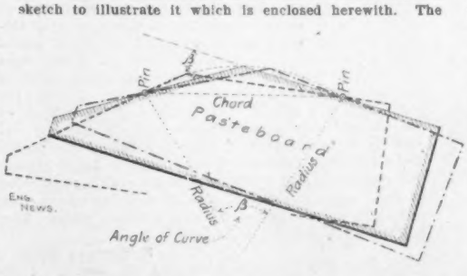
In Wiley's "Principles and Practice of Agricultural Analysis," Vol. I., pp. 171-281, will be found a discussion of various methods of separating different sized grains. These may be made applicable to cement by substituting some such liquid as kerosene oil or benzine for water. "Tests of Metals, U. S. A.," 1901, p. 475, gives a description of the separation of the sizes of cement by a winnowing device in which a blast of air is directed against falling grains of cement. A method which allows the material to set in a beaker for a certain length of time and when it is decanted is described by Mr. Allen Hazen in Report of Massachusetts State Board of Health for 1892. The Schöne apparatus as adapted to cement by Dr. W. Michaelis and used by Mr. J. B. Johnson is sketched in Johnson's "Materials of Construction," 1903, p. 412. The best and most up-to-date method of separating soils, and also probably best for cement if properly adapted to the difference in the materials, is Hilgard's churn elutriator, which is described in Wiley's book mentioned above.

Yours very truly, Sanford E. Thompson.

Newton Highlands, Mass., Aug. 15, 1904.

Plotting a Curve of Long Radius.

Sir: The mechanical method of plotting a curve with a radius too long for the use of a beam compass, which was described by Mr. S. T. Armstrong on p. 132 of your issue of Aug. 11, seems to me to be such a handy wrinkle that every draftsman should familiarize himself with it. To make the method a little clearer I have made a sketch to illustrate it which is enclosed herewith. The



piece of cardboard whose vertex traces the arc is shown by hatched lines while the dotted outlines shows its extreme positions.

It may be added that except in the case of railroad curves the central angle β is not generally known to the draftsman, but it can usually be easily found by measuring with a protractor the difference between the respective angles made by the two tangents at the ends of the curve with a vertical or horizontal line.

B. W. C.

Aurora, Ill., Aug. 24, 1904.

Finding the Statical Moment of a Cross-Section.

Sir: Noting your method of finding statical moment for one-half of an I-beam, as given in your Aug. 4 issue, I would suggest that the statical moment for the whole beam equals moment of inertia divided by radius of gyration, both of which are usually given by tables. Thus for a Carnegie 15-in. 42-lb. I-beam,

$$\begin{aligned} I &= 441.7 \\ R &= 5.95 \end{aligned}$$

whence statical moment for half beam as per your example $= \frac{441.7}{2 \times 5.95} = 37.1.$

Your result of 34.19 is, of course, based upon a differently proportioned beam. Very truly,

M. J. P.

Denver, Colo., Aug. 12, 1904.

(The rule above given appears to be not exact, but only approximate. For, we know that

$$\text{Mom. of Inertia} = Ar^2,$$

where r is the radius of gyration around the given axis and A is the area of section. We know also that

$$\text{Statical Mom.} = Ad$$

where d is the distance of the center of gravity of the section from the axis. The rule given by our correspondent is

$$\text{Statical Mom.} = \text{Mom. of Inertia} \div r = Ar,$$

but this is correct only if r were equal to d. As a matter of fact, r is always greater than d, and it will be noted that our correspondent's result (37.1) is greater than our result (34.2). The rule is most nearly exact in the case of I-beams, plate girders, etc., where the metal is mainly concentrated in the flanges. For, if we neglect the web in this case, we have, for the half section to one side of the neutral axis, very closely $r = d =$ the distance from neutral axis to middle line of flange. —Ed.)

Municipal Improvements at Columbus, O., and the 1905 Convention of the League of American Municipalities.

Sir: Columbus is desirous of securing the next year's convention of the League of American Municipalities which this year holds its convention in East St. Louis. We feel that the city of Columbus is particularly well qualified to entertain a convention of such a character, not only because of its central location, and its splendid railroad facilities, and the hospitality of the people, but also for the special reason that some of the largest and most interesting municipal works in the country are moving forward in this city at the present time.

Columbus has under process of construction the largest sewage disposal plant in the world, which will at the time the convention meets next year be so nearly completed as to be of particular interest to all municipal officials.

We will probably have as well an experimental filtration and softening plant for testing purposes, looking to the expenditure of $1,500,000, for filtering and purifying the water supply of the city. We have practically built a new municipal electric light plant at an expense of a half million dollars, and are also building new municipal markets upon an extensive scale. We believe that Columbus has the largest and most extensive market system of any city of its size in the country, which is entirely self-supporting, in that it yields sufficient revenue to take care of its own sinking fund and the expense of repair and maintenance. Our workhouse is one of the largest and best equipped in the country and also supports itself entirely. Columbus has now in process of construction a concrete dam in the Scioto River, over 800 ft. long.

These works will be completed when the delegates who attend the convention arrive next year and will be one of the most interesting features of the kind to be found anywhere. We feel that with these features, as well as many others which we have neither time nor space to mention, Columbus is the logical place for the next convention, and we propose to make strenuous efforts to secure it. Cordially yours,

R. H. Jeffrey, Mayor.

Columbus, O., Aug. 25, 1904.

Analysis of Iowa Well Waters.

Sir: Without doubt the results shown in the "Notes on the Softening of Iowa Well Waters," by Dr. Nicholas Knight, in your issue of Aug. 18 are disconcerting to the advocates of feed water purifiers by the use of heat alone. Dr. Knight has, however, left an opening for criticism of the methods used in determining the quantity of lime-water required for softening the Mount Vernon water, with which the experiments were made. While to "fish" around until the proper ratio of lime water to raw water is found may give results of approximate accuracy, yet it cannot be said to be either rapid or scientific. Of course, the qualitative tests with silver nitrate and phenolphthalein are "more satisfactory," but even these will scarcely

appeal to those who desire a method which is at once rapid and accurate.

In your editorial comment on this paper it seems that you have taken it for granted that the methods described are in general use by those who have made a specialty of water softening. Such, however, is not the case, so that "the difficulties met with in softening hard well waters of complex composition" are, except to the tyro, more imaginary than real, as the art is no longer in the experimental stage. Your injunction relative to the use of heaters as softeners is timely, since complete success with heat alone cannot be attained, if the water contains calcium sulphate. In such instances softening in an independent plant is the only sure means of preventing scale formation in the boilers.

Dr. Knight closes with the remarkable statement: "The lime water can be tasted in the mixture, which is quite unfit for drinking purposes"—remarkable in view of his analysis. It will be noted that the amount of calcium hydrate in this water is too small to be recorded even as a trace. Probably what appeared to Dr. Knight to be a taste of lime water was merely the difference in taste due to the removal of the free carbonic acid and carbonates. So far from being "unfit for drinking purposes," properly softened water is to-day being used with complete satisfaction in large quantities for drinking and other household purposes.

Yours truly,

L. M. Booth.

126 Liberty St., New York City, Aug. 19, 1904.

A Derailment from Spreading Rails on a Tangent.

Sir: I enclose herewith prints showing views of a railroad wreck which occurred at 3 o'clock a. m., June 27, on the Oregon Short Line R. R., 1½ miles east of Cookville, Wyo. The accident occurred on a long tangent when the train was running, according to the engineer's statement, at 50 miles an hour. Apparently the accident was due to spreading of the rails under the drivers of the locomotive. The front view of the locomotive shows that

A DERAILMENT ON THE OREGON SHORT LINE R. R., NEAR COOKVILLE, WYO., JUNE 27, 1904.

the pilot wheels did not leave the rails, and I think it was due to this that the results were not more serious. The track is on a 7-ft. embankment at this place, with pools of water several feet deep on each side, and it is quite probable the train would have plunged off into the pools had not the pilot wheels of the locomotive remained on the rails. There were 30 or 40 people on board the train, none of whom were hurt. The tender, baggage car and mail car turned over on their side, the latter becoming partly submerged in a pool of water. The remaining cars of the train were as I remember two chair cars, a tourist sleeper and a Pullman sleeper. Apparently the train stopped in its own length, since the rear truck of the rear car still remained on the undisturbed portion of the track.

Very truly yours, H. A. Storrs,

Electrical Engineer, U. S. Reclamation Service.

Denver Colo., Aug. 1, 1904.

(A noteworthy feature of the accident is the distance to which the cars were carried to one side of the track, notwithstanding the fact that the head and rear of the train remained in position on the rails.—Ed.)

The Use of Formulas in the Design of Engineering Works.

Sir: The questions raised by your remarks under the above heading in Engineering News of Aug. 18 are far-reaching and merit close examination. My own views and experience lead me to somewhat different conclusions from those which you draw, but I believe this to be owing to the somewhat restricted interpretation which you give to the terms "formula" and "equation." There are two kinds of formulas and equations; one is the rational kind and the other the empirical.

Analysis enables us to solve any problem, even to the intricate movements of the heavenly bodies, when we know all the data entering into it. As regards sublunary matters, the calculation of bridge members which you refer to, is perhaps the best instance. These calculations are strictly rational, being based upon clearly recognized data.

When we pass to another order of problem, such for instance as that propounded by your correspondent regarding the thickness of concrete abutments, we enter a totally different field, and require a totally different kind of formula, namely, the empirical. These formulas, at least the best of them, embody the result of mathematical processes modified by actual experiment; they are the algebraic sum of many observed successes and failures. They are commonly regarded as "rules of thumb"; actually they are in the highest degree scientific. They furnish the only trustworthy guides in the great majority of practical cases, and their use is indispensable in correctly designed work. In what way, for instance, could your correspondent go to work to build his abutment? He must either use an empirical formula, or build at random, as most abutments are built. The theory of the arch and its abutments occupied for a long time both engineers and mathematicians of all countries, notably, perhaps, the French, and the labors of these men, combined with observation of existing structures, have led to the establishment of certain semi-rational and semi-empirical formulas which enable the constructor of to-day to correctly proportion his masonry bridges. I am not speaking now of reinforced concrete structures which have not as yet passed through the period of scientific and practical investigation from which masonry, strictly so called, has triumphantly emerged.

It may interest your correspondent to know that these empirical formulas, as established and used by French constructors, lead to very heavy abutments for sustaining voussoir arches. It has been fully recognized that the first and most important consideration in arch building, the indispensible essential without which every other condition is vain, is an absolutely unyielding abutment. If the abutments are immovable, both horizontally and vertically, it is scarcely too much to say that almost anything in the form of an arch will resist within the limits of the crushing strength of the material, provided there is enough load on it. An arch is the only kind of construction which occurs to me at the moment which is stronger in proportion to the load it bears, within the above limits. There may be others.

The moral of all this is, that as far as my personal experience goes, a formula, rational or empirical, or empirico-rational (preferably the last named), is absolutely necessary in all scientific designing in which the relative proportion of different parts is required to be known. It has been my aim for many years to establish and embody as many such formulas in my own specialties as possible, for my own use and that of others, as your columns may testify. What the guiding principles of engine foundation building are, I do not know, nor if they have been embodied in any brief symbolic expression which is all that an engineering formula amounts to. If they have not, there is a gap in the literature of the subject of which your other correspondent may justly complain. It may be suggested to him, however, that he had better make his foundations pretty solid, both to guard against and provide for the contingency of his engine getting out of line. Also, that a good plan in such cases is to visit and inspect some similar work of standard value. This will be much better than a book.

E. Sherman Gould.

220 West 57th St., New York, Aug. 19, 1904.

Prof. Talbot's Tests of Concrete-Steel Beams.

Sir: Your issue of Aug. 11 contains a paper describing a series of tests on concrete-steel beams made at the University of Illinois by Prof. Arthur N. Talbot. While recognizing the great value of these tests and the discussion of them by Prof. Talbot, the writer wishes to take exception to some of the conclusions reached by Prof. Talbot, bearing upon the proper design of concrete-steel beams. The paper brings out very clearly the four stages of flexure through which a concrete-steel beam passes under load, and which may be briefly summarized as follows:

Stage No. 1. Concrete acting in tension, no cracks in concrete.

Stage No. 2. Concrete not acting in tension, no visible cracks in concrete.

Stage No. 3. Concrete not acting in tension, cracks appear in tension side of concrete.

Stage. No. 4. Elastic limit of steel exceeded.

Prof. Talbot further says:

The composite structure acts as a true combination of steel and concrete in flexure during the first or preliminary stage, and this stage lasts until the steel is stressed to, say, 3,000 lbs. to 4,000 lbs. per sq. in., and the lower surface of the concrete is elongated 1-10,000 to 1-7,500 of its length. During the second or readjustment stage there is a marked change in distribution of stresses, the neutral axis rises, the concrete loses part of its tensional value, and tensile stresses formerly taken by the concrete are transferred to the steel. During this stage minute cracks probably exist, quite well distributed and not easily detected.

Now, concrete-steel beams as designed for practical use must not only meet the requirements of loading, but must be so designed as to properly protect the steel reinforcement from contact with moisture or atmosphere at all times, and in most cases must also be designed to resist fire. These conditions require that cracks, no matter how minute, must never occur in the tension side of concrete-steel beams, for we are depending upon the perfect condition of this same concrete to protect the steel reinforcement.

It follows, therefore, that concrete-steel beams should never be stressed beyond the first stage mentioned above.

Now, within the limits of that stage, that is to say, within the actual working limits of stress, it is immaterial whether a steel with a high elastic limit be used, or a steel with a low elastic limit, the amount of stress which the steel is able to take depending not upon its ultimate strength or its elastic limit, but upon the value of its coefficient of elasticity, which is practically the same for both grades of steel. The writer does not wish to be understood as advocating any particular form of patented bar, but it is a well-known fact that "soft steel" having an elastic limit of approximately 34,000 lbs. per sq. in. is a more reliable and uniform material than the "high steels," and the writer, for one, would prefer to use it in concrete-steel construction.

Prof. Talbot further says:

So far as strength of beam is concerned, steel having a high elastic limit is advantageous.

It appears to the writer that the above statement should be modified to read as follows: "So far as the *ultimate strength* of the beam is concerned, steel having a high elastic limit is advantageous, but within the allowable working loads there is no advantage in using the high steel."

It seems to the writer that it is a mistake to base conclusions and formulas for the design of concrete-steel beams upon the conditions of flexure which obtain at the point of ultimate failure of the beam, but that such formulas should be based upon the conditions of flexure which obtain when the beam is loaded with the maximum load which is allowable in practice. It is evident that the two methods will give widely differing results.

Many structural engineers are now basing the factor of safety of steel constructions upon the elastic limit or yield point of the material, as that limit is, to all practical intents and purposes in structural design, the point of failure of the material, and in concrete-steel constructions the point of failure to a structural engineer is the point at which cracks appear in the concrete, and the fact, that a concrete-steel beam before ultimate failure will support a load many times the load that produces cracks in its under surface is of no practical benefit.

Yours very truly, Wilbur J. Watson,

Bridge Engineer, The Osborn Engineering Co.

Cleveland, O., Aug. 26, 1904.

More Concerning Engineers' Estimates.

Sir: Engineering News of Aug. 11 contained a very able article on 'Engineers' Estimates of Cost," and an editorial comment upon the same. As the subject merits thorough discussion, the writer desires to broaden the field a little by calling attention to one or two features not specifically mentioned in either article.

It is true that engineers' estimates for large undertakings of a public nature do not command very great respect, and, as a natural result, the general public is of the opinion that the average engineer cannot tell, in advance, what a given undertaking will cost. The example cited by Mr. Whinery, the Erie Canal, affords a striking illustration upon which the public can justly base its opinion, as well as a very pertinent case by which to introduce one of the features not specifically mentioned.

It is this: In estimating the cost of projected works, engineers very frequently neglect to make a thorough study of the ground through, or upon which the works are to be constructed. That is to say, they see nothing below or beyond the visible topographical features. Even where borings are made, no notice is taken, or record made, other than to note the mere differences of loam, clay, sand or rock, without reference to currents of water, other than such as are visible upon the surface, or to

the stability of the soils, other than to rather empirically assume an angle of repose, or a sustaining power for the varieties noted.

In the late attempt to enlarge the Erie Canal, great expense was incurred by reason of landslides and insecure banks. The writer does not claim to have seen or studied the data obtained by the surveys which have since been made, nor to say that the estimates do not provide for such contingencies, but he does say that the failure to recognize the existence of underground waters is not an unusual omission, and a frequent cause of such great expense as to render preliminary estimates of cost entirely misleading. An example or two may be cited.

A paper was recently presented to the American Society of Civil Engineers under the title of "A Phenomenal Landslide," describing the construction of reservoirs at Portland, Ore. The article was well written and illustrated, affording a valuable contribution upon the subject, and showing that it required those engineers several years of time and labor to learn what Nature is doing in that soil, and that her efforts can easily be directed and aided, but that it is not practicable to resist them. Had existing conditions been clearly understood by the engineer who designed those reservoirs, as they might have been had he properly interpreted the evidences as described in the paper, much time, labor and expense, would have been avoided.

A few years since the writer was employed by a construction company that had undertaken to construct some miles of the summit level of the Illinois & Mississippi (the old Hennepin) Canal, and had encountered serious difficulties. An examination of the territory revealed the fact that the canal had been so designed that when completed the surface level of the water in the canal was to be some 5 ft. below the lowest level of water known to exist in the sloughs through which it was to pass, and that this level of ground water covered an area of several square miles. Extensive efforts had been made to drain the sloughs, but the soil was so unstable that ditches were ineffective. Inasmuch as the canal was to have a navigable depth of 7 ft. and be without current other than that induced by the draft of water to operate locks at either end of the summit level, and the contract contained no provisions for drainage, the contractor was practically required to make an excavation with specified slopes, tow-path and berm bank through a lake several feet below its surface. Of course the contract had to be cancelled, the right of way abandoned, and, it is said, that a new location has been made, and that work is progressing in accordance with revised plans.

Incidentally, it may be proper to here refer to the editorial, which asks for estimates of returns, as well as of cost. If any engineer is able to demonstrate that the facilities for inland transportation are to be so benefited by constructing a 7-ft. canal connecting the Illinois and Mississippi Rivers as to afford large returns upon its cost, he has acquired knowledge that has remained hidden from the great majority of his fellow laborers in the field of engineering.

The cases cited are sufficient to show that it is not an uncommon thing for works to be planned and estimated upon, where the engineer has no adequate knowledge of the ground in or upon which his structures are to be located, and that from this cause estimates of cost are frequently found to be misleading. Very few engineers are practical geologists. Very few of the young men who have graduated from engineering schools, when taken to a stone quarry, can tell to what geological formation the rock belongs, or can describe the characteristics of the different formations. When a hillside is moving, an embankment sliding, or a foundation yielding, it is common to call upon an engineer to devise some method of arresting the motion. Unless he can correctly determine the cause, or causes, is he competent to apply the economical remedy? Is it not true that these expensive occurrences frequently result from the failure of the engineer to properly understand the natural forces at work in the soil upon which he is building? There is a society for the promotion of engineering education. Would it be improper for that society to urge that the student of engineering, after getting the little outline of geology taught in the schools, should be taken out to the hills and the swamps, and be shown what Nature has done, what she is now doing, and how she does it, so that he can read and interpret some of those natural forces which he proposes to direct for the benefit of man? If the engineer is no better versed regarding these things than the average business man, has such an engineer just cause to complain when the business man finds that estimates of cost have been inadequate?

In the majority of the larger undertakings the method of procedure is such that no preliminary estimate is made for which any engineer can properly be held responsible. Two Cincinnati examples may be cited. Something more than 30 years ago the city of Cincinnati decided to construct a Southern railroad. A chief engineer was employed, and two or three parties were placed in the field, making preliminary surveys. After about two years of such work it was decided that ten millions of dollars would defray the cost of constructing such a railway. A principal and consulting engineer was placed in charge of construction. This engineer, acting under the instructions of the board of trustees, planned and constructed quite a different character of road from that which had been estimated upon by the engineer in charge of surveys. As there had been no located line, it is plain that no reliable estimate of cost could have been made. Yet the impression still remains in the minds of the people that the original estimate of cost made by the engineers was $10,000,000, as an issue of bonds in that amount was authorized by vote of the people. When that fund was about exhausted another bond issue was submitted to vote and duly authorized. The line had then been located, work was well under way, and the character of the construction determined upon. Six millions of dollars were obtained. The constructing engineer must have known that that sum would be inadequate, or his estimates were inaccurate. Mr. Whinery was then employed in the engineering department of that road, but he may not be able to explain the discrepancy. It was not thought advisable to go before the people on another estimate of cost made by an engineer, so a written proposal was obtained from a reliable contracting firm to complete the road into Chattanooga for the sum of $2,000,000, and that amount of bonds was authorized by the votes of the city. The line was thus completed without proper terminals, but the people remain skeptical about engineers' estimates of cost.

A more recent example may be pertinent. Some 15 years ago, the board then having in charge the city waterworks, decided that betterments should be made or new works constructed. In order to learn what this would cost a commission was appointed who employed three "expert" engineers who were summoned to Cincinnati, quartered at a prominent hotel, provided with carriages and such assistance as they desired, and, in the course of a week or ten days, they produced the required estimates of cost, one for new works in one locality, and another for works in a different place. The question of issuing the bonds and building the works was submitted to a vote of the people and rejected. So long as engineers will consent to make estimates of cost in such a manner as that, they should not complain when people lack faith in them.

Eight years ago another attempt was made for the betterment of the water-works. An "Engineer Commission" was appointed and Mr. Whinery was one of the three engineers composing it. This commission was directed to make surveys, plans and estimates, and report on or before a specified date. The actual time available was about two months. They worked energetically and accomplished much. Their estimate of cost was $6,500,000. A bill was prepared and passed by the legislature authorizing the appointment of a board to construct the works. The people were not asked to express any opinion about it. The board was appointed, a chief engineer and assistants employed, and work has been in progress for the past seven years. It is now estimated that in 1907 water may be obtained. The original appropriation being insufficient, an additional $2,000,000 of bonds have been authorized, and still other funds will be required.

Now, as to the original estimate, Major Whinery cannot be criticized because the cost of the work is in excess of his estimate, as the board and its engineers are not building the works which he and his colleagues designed. The Engineer Commission proposed to treat the Ohio River water by sedimentation and slow sand filtration. The present board erected an experimental filtration plant, and by operating it a year arrived at the conclusion that this method is not, at all times, applicable to Ohio River water, and just what will be done has not as yet been made public, but mechanical filtration may be adopted. If the Engineer Commission prepared unsuitable plans for the work their estimate of cost could have no value, and the engineers cannot escape criticism. The proper remedy for this would appear to be, that engineers should refuse to prepare plans and estimates unless they are allowed the requisite time for investigation. It is true that work of this kind is frequently demanded, and that politicians are usually liberal paymasters, but it is also true that estimates of this character are unreliable, and a fruitful source of criticism to the engineering profession in general.

There is still another variety of estimates about which little need be said, as they are not generally given much thought, except by those who are duped by them. That is the promoter's estimates. The promoter can usually find some party to act as his "engineer," who, upon the slightest provocation, will write up both sides of the account, showing just what a given project will cost and what the investment will produce. The less he knows about it the more readily can he tabulate the figures. Usually neither party waits for revenues to be produced.

The careful, painstaking engineer will still go on his quiet way making his estimates and building the works which he designs, very generally at about the estimated cost, and to him the profession must look for the vindication of the engineer.

M. D. Burke.

4th and Walnut Sts., Cincinnati, O., Aug. 15, 1904.

(A proof of the above contribution was submitted to Mr. Whinery and we append his reply.—Ed.

Sir: I have read with great interest Mr. Burke's communication upon "Engineers' Estimates of Cost," and his incidental comments on my article upon that subject.

It is undoubtedly true that many cost estimates are unreliable and erroneous, because of the lack of sufficient data upon which to base a satisfactory estimate; and that this condition is not usually the fault of the engineer, whose clients may not have afforded him the time and means required to make such surveys, examinations and studies as he well knows are necessary in order to make a satisfactory estimate of the cost of the work. All the engineer can do in such cases is to call attention to the facts, and make clear the limitations under which the estimate is offered. If the client demands, and is satisfied with a professional guess, he is perhaps entitled to it, but it should be distinctly so labelled. The writer intended to cover this point in saying:

"The extent and character of the surveys and examinations made, and the measure in which they are regarded as adequate to disclose the quantity and the nature of the work to be done, should be stated."

But the matter might well have been enlarged upon, and given more prominence.

In regard to the two specific cases referred to by Mr. Burke, with which the writer was personally connected, he feels some delicacy in speaking freely, particularly in the case of the Cincinnati Southern Railroad, in which enterprise he held, at the time the inadequate estimate referred to was made, a very subordinate position.

It is true that the estimate of cost of that road, based upon the preliminary surveys, was about $10,000,000, and that the final cost was about $18,000,000. A discussion of the causes that led to this discrepancy would hardly be profitable now, but it is pertinent to the subject under discussion to say that it is always unwise to base financial arrangements for the construction of any new railroad, upon estimates derived from preliminary trial lines. Such estimates are necessary and have their place and value, but the client should be made clearly to understand their unreliability; and that a satisfactory cost-estimate can only be prepared after the final location has been made, and the necessary investigation completed.

As illustrating the difference in value between estimates based upon preliminary surveys and those based on final location, the writer may be pardoned for mentioning that in the case of the Chattanooga Division of the Cin. Sou. R. R., constructed under his charge, his cost-estimate for grading and masonry, made after the final location of the line, exceeded the actual cost by less than 5%.

In regard to the Cincinnati Water-Works, it may be sufficient to mention that the trustees could, at the time, have contracted with a responsible company for the construction of the works for the sum named in the Engineer Commission's estimate of cost. This is said without any intention of criticizing either the revised plans finally adopted after more careful investigation than the time at the disposal of the Commission permitted, or the management of the construction work by the engineers and the trustees.

Inasmuch, however, as one of Mr. Burke's sentences might be construed as intimating that a blunder was made by the Engineer Commission in the matter of the general plan of filtration recommended, it may not be improper to say that the experimental filtration plant (which, by the way, had been recommended by the Commission) clearly demonstrated that water of undoubted purity and wholesomeness, could be obtained by the slow sand filtration recommended; but it was found that a minute portion of very fine clay, sufficient at times to give a tinge of color to the water, would pass the sand filters, and it was deemed best, by the able engineers in charge of the work, to provide for removing this slight discoloration, for the sake of improving the appearance of the filtered water, rather than because it was necessary for hygienic reasons. It may be an open question how far it is advisable or justifiable to increase the cost of a water system to remove even the *appearance* of impurity, but that is "another story" not apropos here.

S. Whinery.

New York, Aug. 20, 1904.

Notes and Queries.

In the heading to the article "Some Recent Elevator Accidents" which appeared in our last issue, the author, Mr. Edward Van Winkle, was by an error denoted "Assoc. M. Am. Soc. C. E." This should read "Assoc. Am. Soc. M. E."

C. F. B., New York City, desires a device for automatically opening or closing a valve on a water pipe, in accordance with changes in steam pressure and also with changes in temperature. Can any one give information as to the makers of any such device?

REPORT OF THE CORONER'S JURY ON THE DENVER & RIO GRANDE R. R. TRESTLE DISASTER OF AUG. 7.

In our issue of Aug. 11 we briefly recorded the terrible disaster of Aug. 7, which occurred on the Denver & Rio Grande R. R., about 6 miles north of Pueblo, Colo. A heavily loaded World's Fair passenger train ran into a trestle across an arroyo which was filled with a torrent as a result of a very heavy local shower. The locomotive and the

first two cars went down with the trestle; and of those whom they carried, 88 bodies have been recovered while 8 are missing. The three rear cars of the train remained standing on the track back of the trestle.

The verdict of the coroner's jury, as reported by "The Railway Age," was as follows:

Bridge 110-B was a wooden structure, consisting of three spans, each 32 ft. in length, and resting upon four bents. Numbering the bents from north to south, one and four consisted of posts standing on blocking and caps above supporting stringers, ties and rails. Bents two and three consisted of seven piles driven 13 ft. into the bottom of the channel and sawed off 6 ft. below the surface. On top of these piles rested a sill 12 × 12 and fastened to them with two drift bolts, each ¾-in. in diameter and 36 ins. long, driven through the sills into each of the piles. Resting on the sills of each bent and extending to the cap above were seven 12 × 12 posts, each fastened to the sills with two drift bolts ¾-in. in diameter and 22 ins. long, driven through the sides of the posts obliquely into the sills. The outer posts on each side of the row of seven rested on the sides at an acute angle to afford the structure greater horizontal or side resistance. On top of the posts were placed caps 16 × 16, which were fastened to them by two drift bolts ¾-in. in diameter and 26 ins. long, driven through the caps into the top of each post. The stringers were each 8 ins. × 30 ins. × 32 ft. best Oregon timber. Four of these were bolted together and placed under each rail, making eight in all stretching from bent to bent. The ends of the stringers were joined by butt joints. Resting on the stringers were the ties and on these the rails. The outer one of each set of four stringers was fastened to the cap below by means of a ¾-in. bolt, with nut on each end, which bolt passed through the cap, stringer and tie above.

The jury summarizes its conclusions as follows:

(1) The water not being over the tracks at the bridge, but several inches below the banks, neither the engineer nor the fireman could possibly see it. The track being in line and level nothing wrong with the bridge could possibly be seen by them. The fact that when the first impact took place the Pullman passengers were not thrown forward out of their seats, besides positive testimony on the point, shows the train was running slow, according to orders, and the crew is therefore blameless.

(2) If the county bridge was a factor in the destruction of bridge No. 110-B the railroad company was to blame for not constructing a bridge that would avoid or withstand its impact, as it knew the county bridge was there.

(3) Had a bridge of one span on abutments with no obstructions in the channel of the stream to obstruct the flow of water or passage of debris, or stone arches of equal capacity to arroyo, stood in place of bridge No. 110-B it would have in all human probability withstood the force of both the volume of water and the impact of the county bridge (if the latter took place) and the catastrophe would not have occurred.

(4) Bridge No. 110-B was not of the best class of bridges used by railroads throughout the country.

(5) Inspection close up to the time of the wreck showed bridge No. 110-B to be in its usual condition. Its weakness considered, not in its condition, but in the cheap, inferior class to which it belonged.

(6) Had the heavy downpour in the vicinity of Eden at 7.13 p. m. been reported to the train dispatcher at Pueblo, he might have delivered additional caution orders to No. 11 at Buttes before she left at 7.30, and the disaster might have been averted.

(7) The conductor of No. 7 reported water over the track two miles south of Eden on arrival at Pueblo at 7.55 p. m. and a downpour at Eden, and had a night operator been stationed at Wigwam, eleven miles from bridge No. 110-B, or at Pinion, five miles from it, train No. 11 could have been warned and the disaster averted.

(8) Had a regular system of track-walkers and flagmen, independent of the section men, been maintained by the company over the track in question, especially in the afternoons, evenings and nights, during the rainy season, No. 11 could have been flagged and the disaster averted.

(9) Had bridge No. 110-B been under charge of the section gang at Eden, one mile away, instead of the one at Pinion, five miles away, No. 11 would have been flagged and the disaster averted.

(10) Bridge No. 110-B should have been so constructed as to withstand all the water the arroyo could accommodate. On the night in question the arroyo accommodated all the water that came down, but the bridge collapsed.

(11) If bridge No. 110-B had been a one-span metal bridge with stone abutments the probability of damage by the county bridge would have been much lessened.

Therefore, the jury finds that the appalling loss of life and property at bridge No. 110-B on Aug. 7, 1904, was due to the negligence of the Denver & Rio Grande Railroad Company as set forth in the foregoing statement of findings and conclusions.

GOVERNMENT CIVIL SERVICE EXAMINATIONS, soon to be held, include the following which may be of interest to engineers:

Mechanical Draftsman, Ordnance Department at Large, at $1,200 per annum. Examination, Sept. 21 to 23, 1904, at all large cities throughout the country. The minimum age limit is 20 years.

Electric Elevator Constructor, at $4 per day. Full theoretical and practical knowledge of the latest forms of electric elevator control is essential. Applicants will not be examined unless they have had practical experience in building and installing the most modern types of elevators. Examination, Sept. 14, 1904, at all large cities throughout the country.

Cartographic Draftsman, Naval War College, Newport, R. I., at $1,200 per annum. The position involves some typewriting work in addition to the duties of draftsman. Examination as soon after Sept. 1, 1904, as practicable.

The first two examinations are under the United States Civil Service Commission. Requests for application blanks should be addressed to that commission at Washington, D. C., or to any local secretary of board of examiners. The application must be filed at Washington in time to permit shipment of examination papers to the desired place of examination. The examination for Cartographic Draftsman is directly under the Naval War College. Applications should be addressed to "President, Naval War College, Newport, R. I.," and must be accompanied by statements of age, residence, citizenship, present and previous occupation or work done, and by evidences of citizenship and certificates as to character, habits of industry and sobriety, skill and experience in doing the class of work desired. Applicants will be informed of the date upon which they will be required to report for examination.

ELECTRIC OPERATION OF SUBURBAN TRAFFIC near New York City is actively contemplated by the New York, New Haven & Hartford Ry. The scheme has been developed in detail, and estimates of its cost have been made. It involves six-tracking the Harlem River branch of the line (from Willis Ave. and Harlem River, New York City, to New Rochelle, N. Y.) and equipping four of the tracks for electric trains, leaving two tracks for through service by steam. It is proposed to make connection with the New York Rapid Transit Ry (subway) at West Farms, in the Borough of The Bronx, New York City, so that the suburban trains can be run down the subway to lower New York City. It is also planned to build a connection with the Long Island R. R. by means of the bridge crossing over the East River at Randall's and Ward's Islands, which crossing is part of the Pennsylvania Co.'s tunnel system at present under construction across New York City to the Long Island R. R. The proposed connection would give the Pennsylvania trains from the West a direct outlet to New England. The entire plan of the New York, New Haven & Hartford Ry. involves an estimated expenditure of at least $8,000,000.

AN ELEVATOR ACCIDENT in the soap factory of B. T. Babbitt, 64 Washington St., New York, caused the death of four men on Aug. 27. The elevator was an old steam-operated machine. A new cable had been placed on it a few weeks ago. While the elevator was going up with a load of several carboys of acid and three men besides the operator, the rope pulled out of the socket in the crossbeam on the elevator, and the car fell four or five stories to the basement. Two of the men were killed outright, while the other two died a few hours later. All were badly burned by the acid.

A RAILWAY WATER TANK COLLAPSED at the Grand Trunk Yards, Charlotte, Mich., on Aug. 18. The tank was supported on a timber trestle.

THE FRENCHMAN'S BAY COALING STATION of the U. S. Government, at East Lamoine, Me., was badly damaged by a severe wind storm on Aug. 20, 1904. The station was described in Engineering News of July 24, 1902 (p. 58). It comprises a coal-storage house on shore, a pier built parallel to the shore some distance out, and a connecting structure. The pier carries two traveling coaling towers about 130 ft. high, each fitted with a 75-ft. boom on the seaward side and a 35-ft. boom on the landward side. One of these towers was overturned by the gale of Aug. 20 and fell upon a scow and a small auxiliary coal-storage house alongside the main pier.

CHICAGO'S PNEUMATIC MAIL TUBE SYSTEM was turned over to the Government Aug. 24. The system consists of nine miles of brass tube, through which mail is transported by compressed air to various stations, including those located at all railway depots. The system is the largest thus far installed in the United States. It connects the new (unfinished) post office, temporary post office, three branch post offices, and the Chicago & Northwestern, Illinois Central, Union and La Salle railway stations. The system was installed by the Chicago Postal Pneumatic Tube Service Co., which will receive $120,000 annually from the post office department.

THE LARGEST TURBINE VESSEL yet built, the "Victorian" of the Allan Line, was launched at Belfast, Aug. 25. She is 540 ft. long, has 60 ft. beam, and her depth is 40½ ft. It is expected that she will be ready for service before the end of the year.

THE SLIDING OF A MASS OF WET EARTH has destroyed 600 ft. of wharf along the river line of the Texas & Pacific Ry. grain and cotton terminal at Westwego, La., opposite New Orleans. Fortunately the wharves were clear of freight and no ships were moored alongside, consequently the damage was comparatively slight. The cause of the accident is said not to have been the undermining of the bank by the river current, as at first supposed, but it appears that the sliding of the earth was due to the accumulation of sediment on the batture (river bank) during high water. The rapid fall of the river left a heavy, unctuous deposit on the batture, which, after being rained upon, slid in a compact mass, putting such a pressure upon the piles of the wharf that they gave way. The crash of the falling section of wharf was heard for miles. The rest of the wharf, which was originally 1,200 ft. long, was saved by playing streams of water on the batture, using pumps on tug boats, thus washing away the earth before it could slide. This hydraulicking is still going on, and the damage to the wharf is being repaired.

THE 16,000-TON BATTLESHIP "LOUISIANA" was launched at the yard of the Newport News Shipbuilding & Dry-Dock Co., Newport News, Va., on Aug. 27. This vessel is the first of a group of five 16,000-ton battleships which Congress authorized several years ago. The "Louisiana" is being built in competition for speed with a sister ship, the "Connecticut," which is being built at the New York Navy Yard of the government and will be launched in a few weeks. The "Louisiana" has the following dimensions: Length on load water line, 450 ft.; width outside of plating, 76 ft. 8 ins.; normal draft, 24 ft. 6 ins.; engines, 16,500 I. H.P.; speed, 18 knots. The engines will be two vertical triple-expansion engines running at 120 r. p. m., with cylinders 32½, 53, 61 and 61 ins. by 48 ins. stroke. Steam at 265 lbs. pressure will be supplied by twelve Babcock & Wilcox boilers, with a total grate surface of 1,100 sq. ft. The main armor of the vessel includes a complete water line belt 9 ft. 3 ins. wide amidships, varying from 4 ins. to 11 ins. in thickness; casemate armor 6 and 7 ins. thick; 8 to 12-in. armor on the large (12-in.) turrets, and 6 to 6¼-in. armor on the 8-in. turrets. The main battery will consist of four 12-in. rifles, in two turrets, and eight 8-in. rifles, in four turrets. The vessel will have a complement of 41 officers and 778 men.

BIDS FOR A REINFORCED CONCRETE STANDPIPE at Attleboro, Mass., in accordance with the specifications outlined on p. 94 of our issue of July 28, 1904, were five in number, and ranged from $33,679 and $75,000. The contract was awarded on Aug. 25 to the Aberthaw Construction Co. at $34,365. Each bidder submitted plans for the work, and the plans were judged chiefly by the sectional area of steel and the methods of concrete waterproofing proposed. T-bars, twisted bars and corrugated bars were proposed by the various bidders, each bidder except the successful one specifying about the same amount of steel reinforcement in the sides, although differently distributed. The greatest variation was in the steel used vertically. The successful bidder offered, as an extra precaution against ice, an additional factor of safety in the upper part of the structure. As a rule, a coat of plaster, composed of cement, sand, soap and alum, was proposed by the various bidders as a method of waterproofing. An addition of glue and plaster was proposed by the successful bidder. Probably construction will not be started before the spring of 1905. The engineers for the stand-pipe are Snow & Barbour, Tremont Bldg., Boston, Mass.

THE SUIT BROUGHT AGAINST THE CITY OF PAWtucket, R. I., by the American Sewage Disposal Co., for alleged infringement of patents relating to sewage treatment has been decided against the company by Judge Brown of the U. S. Circuit Court. The patent involved was No. 559,522, issued May 5, 1896, to the late Amasa S. Glover. The claims comprising this patent were given in our issue of Aug. 11, in a note appended to a letter which appeared on p. 133 of that issue.

PROGRESS ON THE SIMPLON TUNNEL during the month of July, 1904, is reported from official sources in the "Schweizerische Bauzeitung" as follows: Advance of south heading, 209m. (685.5 ft.). This makes the total length of the south heading 8,928m. (29,284 ft.). The north heading has lain idle since work was interrupted by excessive flow of water on May 18, 1904, when that heading had reached a total length of 10,376m. (34,033 ft.). The aggregate length of both headings is, therefore, 19,304m. (63,317 ft.) The length of the tunnel when completed will be 19,729m. (64,711 ft.), so that on Aug. 1, there was a length of 425m. (1,394 ft.) remaining to be penetrated by the headings. The preceding figures all refer to the main headings, which are bottom headings. The heading of the parallel tunnel and the top heading of the main tunnel are, of course, somewhat behind the bottom or advance heading, while the full-section excavation and the lining work are, again, behind these.

AUTOMOBILE TRANSPORTATION is one of the features of the transportation facilities at the St. Louis exhibition, supplementing the electric railway and the wheel chairs. For this service the Auto-Car Equipment Co., of Buffalo, N. Y., has furnished 50 vehicles, carrying 20 passengers each, on transverse seats. They have a wheel-base of 8 ft. 10 ins., and weigh 5,500 lbs., of which the 42-cell Exide storage battery represents 2,000 lbs. There are two 5-HP. Westinghouse 85-volt motors; these operate independently, and each transmits its power directly by a flexible roller-bearing chain to a sprocket wheel on the rear driving wheels. The car can run 40 miles on one charge of battery, and has speeds of 3, 6, 9 and 12 miles an hour.